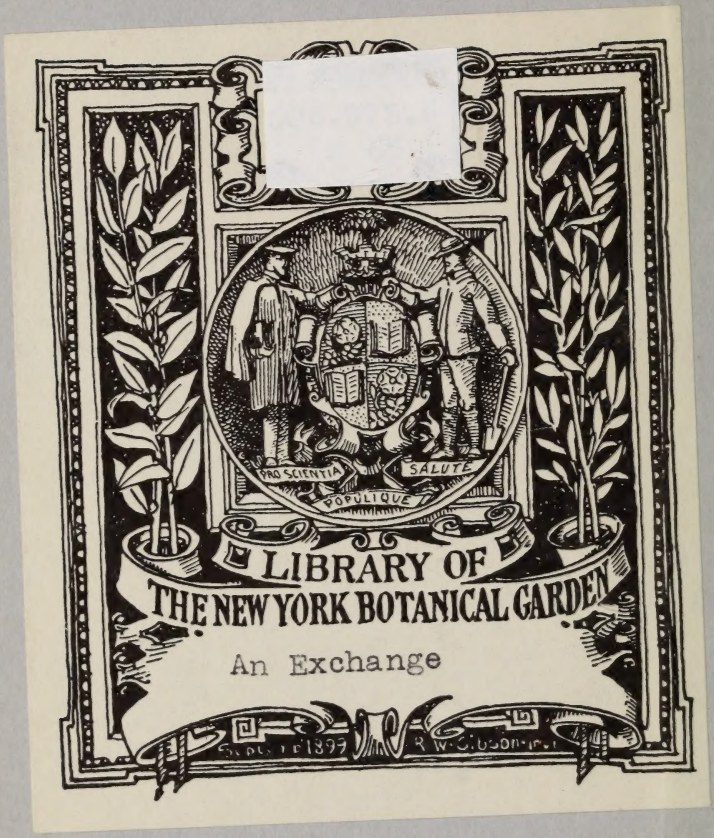
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A Journal of Scientific Investigation and Research

THEODORE H. HUBBELL, *Editor*

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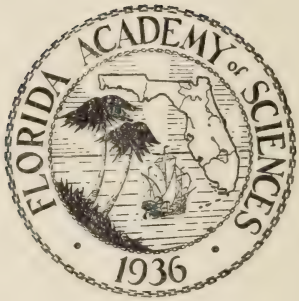

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VOL. 8 MARCH, 1945 No. 1

CHRONOLOGY OF THE PLEISTOCENE ÉPOCH

RICHARD F. FLINT, MAJOR (AIR CORPS)

AAF Tactical Center, Orlando, Florida

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  - Rate of sedimentation
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SUMMARY

One of the great geologic advances of the 20th Century has been the development of a method of dating more or less accurately, in terms of actual years, definitely known points in geologic history. As a result our perspective of geologic time has been vastly enlarged, and we have gained a more accurate concept of the time involved in the evolution of animals and plants. Within the last few decades attempts have been made to arrive at an absolute time scale for Pleistocene events, with all that the possession of such a scale would imply for an understanding of the growth and decay of vast glaciers and of the evolution of man. Although a good deal of ingenuity has been expended on the matter, the results thus far obtained are only estimates, and all are unsatisfactory because they are unavoidably inaccurate. The best of them have hardly yielded more than an idea of the order of magnitude of the time involved.

Ever since Agassiz proposed the Glacial Theory geologists have inferred that the Ice Age came very late in the geologic record, because glacially smoothed and striated bosses of bedrock were seen preserved in virtually original freshness. Soon afterward morainic topography, unfilled small basins that had contained lakes, and similar evidences of geologic recency were noted, but all such features are far from giving any precise concept of the length of time since they were made, because the factors involved in their preservation are variable. In Yosemite Valley, Matthes (1930: 69) notes that where siliceous granite is in contact with diorite, the granite "gleams with glacier polish, whereas the diorite has a roughened and perceptibly lower surface." If these two rock types were not in contact, but occurred in different districts within the same region, their different surfaces might have been interpreted as the products of two different glaciations. In this case the variable is lithology. In another it may be climate; in still a third, angle of slope. In every case, even with the greatest caution, the results of our calculations are necessarily coarse.

The attempts at an absolute rather than a purely relative chronology of Pleistocene events fall into two groups: those aimed at the determination of postglacial time and those looking toward the dating of events farther back in the Pleistocene. The majority fall into the former group, seeking to determine the time that has elapsed since some identifiable event in the last deglaciation. This is largely because the available evidence is clearer than for earlier events.

POSTGLACIAL CHRONOLOGY

Postglacial is a term that, strictly speaking, can be applied to only one locality or district. Events that took place while the dis-

trict was last covered with glacier ice are referable to glacial time; subsequent events are referable to postglacial time. Since removal of the glacial cover was progressive, it follows that postglacial time began for some districts much earlier than for others, and that for most of Antarctica and Greenland, for example, postglacial time has not begun yet. The term postglacial is sometimes applied to events in regions that never were glaciated, but in which the indirect effects of glaciation are clearly marked, as for example the valleys of large streams whose headwaters drain glaciated regions. The cessation of outwash deposition and the beginning of trenching of the outwash by nonglacial runoff is an event that can often be definitely recognized and that can with propriety be considered as marking the transition from glacial to postglacial time in a given valley or valley system. Where there is no direct connection, such as is afforded by outwash, between a glaciated and a nonglaciated district the term postglacial is hardly applicable to any feature in the nonglaciated district. For the desert basins of western United States, where Pleistocene features record alternating episodes of moisture and dryness, terms such as pluvial and postpluvial are sometimes used (cf. Antevs, 1936).

The length of postglacial time in any given region has been approached in two ways: through the study of varved lacustrine sediments and through extrapolation backward on measured or estimated rates of natural processes still in progress. We shall begin with the second.

Extrapolation on Rates of Present-Day Processes

All attempts at extrapolation either carry the expressed or implied assumption that the rate has been constant, or must make allowances for past variations in rate. Further, in most cases the time of inception of the process can not be definitely fixed. These disadvantages are common to the group; in addition, specific problems involve other, individual difficulties.

Rate of Erosion

Retreat of Waterfalls: Niagara. Niagara River cuts through a cuesta that separates the basin of Lake Erie from that of Lake Ontario. The cuesta is formed by a resistant dolomite overlying a weak shale. Largely by undermining of the dolomite, the falls have migrated 6.5 miles up the river from the cuesta scarp, leaving a gorge of variable width through this distance (Fig. A).

The falls are believed to have come into existence at a time when an ice sheet, shrinking away toward the north, uncovered the cuesta and permitted water that had been ponded by the ice in

the Lake Erie basin to spill northward into the much lower basin of Lake Ontario newly freed of glacier ice. At first it was believed that these events occurred entirely during the Wisconsin age. On this basis Gilbert (1895: 234) wrote: "To measure the age of the river is to determine the antiquity of the close of the ice age." For a long time it was thought that the chief fall, the Horseshoe Fall, was retreating at a rate of about 5 feet per year, and that dividing this annual rate into the total length of the gorge would measure postglacial time for the Niagara district. Then it was found that the discharge of Niagara River had amounted at times to more than twice its present discharge and at others to a small fraction of this quantity. Further it was realized that the level of the lake in the Ontario basin had been high enough to reduce the drop of the falls by half. Both these factors introduced important variables into the calculations, and despite ingenious estimates of the discharge at various times, the closest time estimate of the age of the gorge that could be made in 1913—20,000 to 35,000 years (Taylor, 1913: 24)—involved a large margin of error.

It was shown later, however, (Johnston, 1928) through borings made for a railroad bridge, that the middle part of the gorge—the Whirlpool Rapids Gorge (Fig. A)—contains a thick fill of glacial drift, and hence that it must be a pre-Wisconsin (probably interglacial) gorge that was filled with drift and then partly re-excavated in postglacial time. If this is true, then the age of Niagara gorge as a whole can not be determined, as we have no way of fixing either the rates of cutting or the dates of the parts of the gorge that antedate the last glaciation. We are obliged to fall back on the Upper Great Gorge, the uppermost segment of the whole gorge, which appears to be genuinely postglacial. New determinations by W. H. Boyd show the present rate of recession of the Horseshoe Fall to be not 5 feet, but rather 3.8 feet per year (Johnston, 1928). Hence the age of the Upper Great Gorge is calculated at somewhat more than 4000 years—and to obtain even this figure we have to assume that the rate of recession has been constant, although we know that discharge has in fact varied greatly during postglacial time. Accepting Johnston's data, Taylor (1929) revised his interpretation; this, however, added nothing in the form of exact chronology. In summary, the history of Niagara Falls as we now understand it does not furnish a basis for determining the duration of postglacial time.

St. Anthony Falls. Like Niagara, the St. Anthony Falls of the

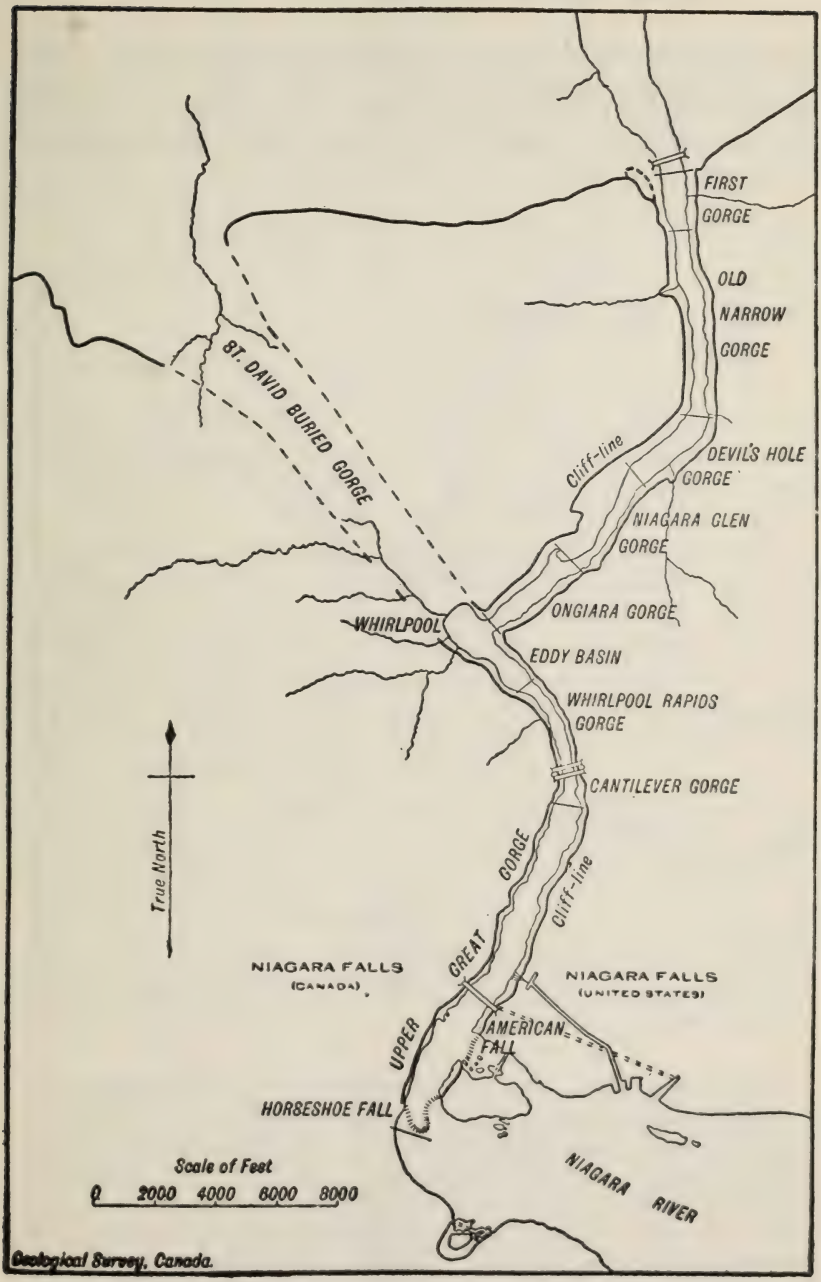

FIG. A.—Plan of Niagara Gorge and surroundings. (Antevs, Geol. Surv. of Canada).

Mississippi River at Minneapolis are related to postglacial drainage; like Niagara, the gorge below the falls is nearly 7 miles long; and like Niagara, the downstream end of the gorge is an exhumed valley of pre-Wisconsin date. Like Niagara, these falls have been made the basis of estimates of postglacial time.

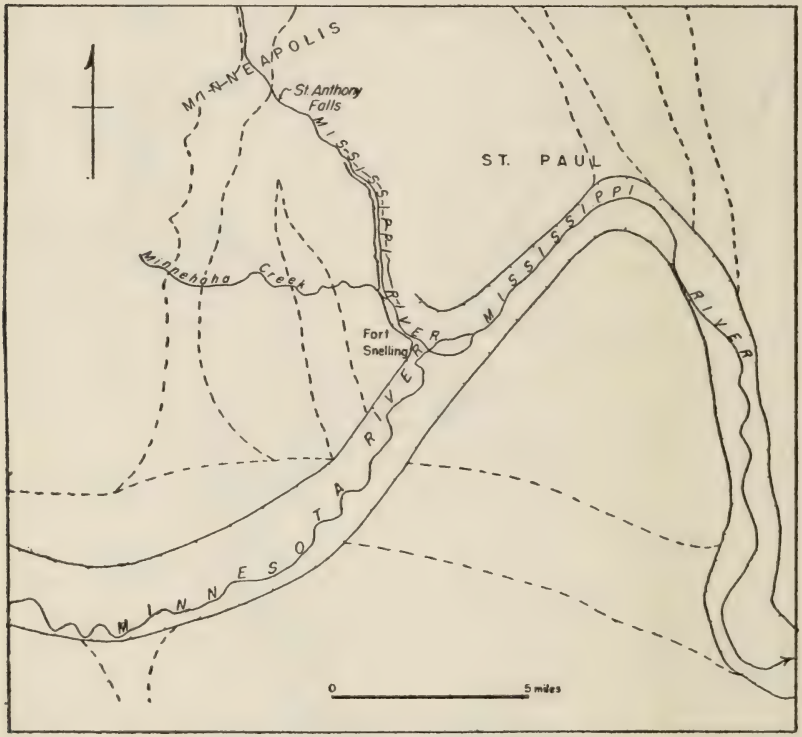

Fig. B—Plan of vicinity of Minneapolis-St. Paul, showing St. Anthony Falls and features referred to in the text (modified after G. M. Schwartz, Minn. Geol. Survey).

In pre-Wisconsin time the Minneapolis-St. Paul district, in Minnesota, had a system of stream valleys (Fig. B) with which the modern valleys are coincident only in part. Wisconsin glaciation completely filled the old valleys with drift, and the meltwater streams of earlier postglacial time took new routes over the drift surface. In time the postglacial main stream discovered the buried valley in the southeast part of St. Paul, rapidly re-excavated it, and, where it flowed over the side of the exhumed valley, formed a falls. As this falls retreated past Fort Snelling, where the Mississippi

River joins the Minnesota River, it cleared out a narrow preglacial valley there, and a falls was started in the Mississippi about a mile north of Fort Snelling. This falls—St. Anthony Falls—retreated northward through nearly 6 miles, and still exists, but the main falls, retreating southwestward, intersected another preglacial valley and was thereby extinguished.

For nearly 3 miles above Fort Snelling the Mississippi gorge is deep and contains a thick fill of alluvium. The 4-mile segment extending thence upstream to the St. Anthony Falls is shallower and contains no alluvium. The difference arises from the fact that the Minnesota River valley first carried the enormous flow of water discharged from Lake Agassiz, and later, when Lake Agassiz drained northward, this discharge ceased, and aggradation by the reduced Minnesota River was the result. The Mississippi, which up to that time had been a mere tributary to the swollen Minnesota, aggraded its valley floor to the rising fill in the master valley.

By comparing maps, sketches, and descriptions dating back as far as 1680, it has been computed that the St. Anthony Falls has retreated at an average rate of 2.44 ft. per year. On this basis Winchell (1888: 337, 341) calculated that about 8000 years had elapsed since falls originated. Sardeson (1916:13) later calculated this period as 12,000 years, of which 8000 have elapsed since the draining of Lake Agassiz and the consequent aggradation of the Minneapolis-St. Paul district.

Unfortunately for the accuracy of these calculations, the rate of recession of the falls was found to have accelerated notably during the time of human observation. Probably this is because the Platteville limestone, the resistant stratum that forms the lip of the falls, thins rapidly in the upstream direction. This factor and the factors of variable discharge and falls height introduce variables into the calculation that can not be overcome. Hence the figures given in the preceding paragraph are not only not accurate but may not even be of the right order of magnitude.

Summarizing the studies of the recession of Niagara and St. Anthony falls, we are obliged to conclude that neither measures the whole of postglacial time for the district in which it occurs, and that in both cases the results are unreliable because of variable factors that can not be evaluated.

Retreat of Wave-cut Cliffs. Somewhat analogously, Coleman (1914) made an attempt to estimate the age of Lake Ontario, which, as he recognized, represents only a part of postglacial time. He

inferred that off the Scarboro cliffs, near Toronto, the shore initially stood 13,000 feet farther out than now, because at that distance the offshore bottom profile abruptly steepens. By comparing the results of successive surveys made during a period of 50 years, he calculated that the cliffs had receded at an annual rate of 1.62 feet. At this rate the inferred initial shoreline of Lake Ontario would date back to about 8000 years ago, a figure which Coleman regarded as a minimum. Accretions of debris from the erosion of the cliffs to the shore farther west were calculated to have required a comparable time for their development.

The Lake Iroquois strandline is as maturely developed as is that of the modern Lake Ontario; by analogy Coleman inferred that its development had likewise required about 8000 years. Several lake stages intervened between Iroquois and Ontario, and in the absence of any time data on these, Coleman guessed that another 8000 years should be assigned to them, making a grand-total estimate of 24,000 years elapsed since Lake Iroquois time, a time when glacier ice still covered most of southeastern Canada.

This estimate was criticized by Spencer (1917). Although we may think his criticism unnecessarily severe, we are obliged to agree that indeed two-thirds of Coleman's result is guesswork, whereas the other third involves several uncertainties. All in all, it is hardly as trustworthy even as the unsatisfactory results of the studies of falls recession.

Erosion of Small Valleys. G. F. Wright (1912) attempted to extrapolate backward on the rate of cutting of an artificially diverted creek in Ohio during a period of observation of 14 years, in order to determine the period required for the excavation of the stream's natural valley—a period just equal, in Wright's opinion, to postglacial time for the district in question. Wright explicitly recognized two variable factors: (1) the decrease in rate of erosion with increasing topographic age of the valley, and (2) the strong influence of forest cover, which was present during most of the cutting of the natural valley but not during the cutting of the valley begun by the diversion. In consequence, the figure arrived at—2500 years—was admittedly much too small and is of little value.

In summary, extrapolation backward on present rates of erosion, even where those rates are fairly closely fixed, is an unsatisfactory method for determining the length of postglacial time. We may now turn to a series of attempts based on rates of sedimentation.

Rate of Sedimentation

Delta Building. One of the sedimentary processes upon which time estimates have been constructed is the building of deltas. Johnston (1921) studied the delta of the Fraser River, which enters the Pacific at Vancouver, B. C., with the object of estimating the time involved in its accumulation. The modern delta of the Fraser lies within and below the remnants of a dissected delta built during a glacial time when the land stood at least 650 feet lower, relative to the sea, than it does now. The modern delta was built after uplift of the land relative to the sea had ceased. It is 80,000 feet long and in one place it is at least 700 feet thick. Measurements made through a 60-year period show that the average rate of seaward advance of the delta front is about 10 feet per year. On the assumption that this rate has been uniform throughout the existence of the modern delta, the age of the delta is 8000 years. The chief variables that have to be neglected in this calculation are (1) variable rate of sedimentation, and (2) variable width and depth of the submerged valley in which the delta is built. Both variables could introduce large errors into the result. Furthermore, it seems very likely that after relative uplift of the land had ceased, the sea level continued to rise eustatically, perhaps for a long time. As long as it continued, such rise would add to the thickness of the delta and reduce the rate of its seaward advance, thus lengthening by a factor that can not now be determined the elapsed-time figure derived solely from the present rate of growth. Because of these variables, the figure of 8000 years can hardly be regarded as even approximate, and even then it is not certain that the delta began to be built as soon as the Vancouver district was deglaciated.

Using a similar method on the Bear River delta at Stewart, in extreme northern British Columbia, Hansen, (1934) derived a figure of only 3600 years. The same method was used earlier by Heim (1894) on the delta built by the river Muota into Lake Luzerne in Switzerland. He calculated that this delta, whose building began with the deglaciation of the locality during the Buhl subage, had been accumulating for 16,000 years. The variables applicable to the Fraser case apply to this case as well. Applying somewhat different values to certain factors, Collet (1925: 256) derives a figure of 13,000 years, which he considers more accurate than Heim's figure.

From an examination of these cases we find that in the study of deltas, as in the study of rates of erosion, it is thus

far impossible to eliminate important variable factors; the results achieved must be viewed in the light of this fact.

Accumulation of Peat. A 39-foot section of sphagnum-moss peat containing spruce stumps, resting on fresh till, at a point 8 miles beyond the terminus of Russell Glacier, in Alaska, provided Capps (1916: 69) with a means of estimating postglacial time at that locality. The peat was frozen to within 6 inches of the surface. The roots of the spruces growing on the surface of the peat and the roots of the spruce stumps occurring throughout the peat section were alike in consisting of a central vertical root

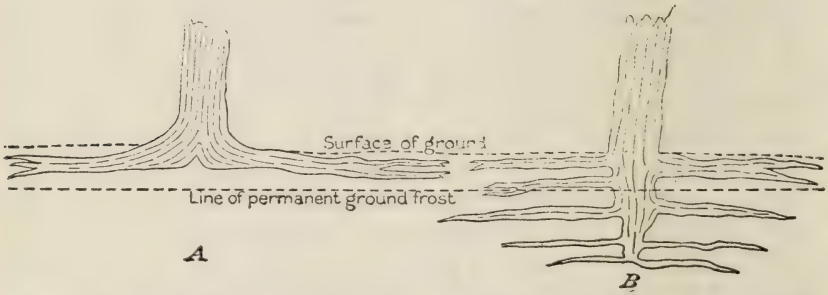

FIG. C.—Roots of a spruce tree (*A*) growing normally on solid ground, and (*B*) growing on rapidly accumulating peat. (Capps).

with several radial horizontal branches. Evidently each radial set of root-branches had been sent out just above the frost line, but the thickening of the moss and the accompanying rise of the frost line froze these roots and forced the tree to send out a higher set (Fig. C). If this is what happened, then the vertical distance between the lowest roots of a living tree and the surface of the ground represents the thickness of peat accumulation during that tree's life. The ages of the living trees being determined by counts of their annual rings, it was calculated that peat is accumulating at a rate of one foot in 200 years, the variable factors involved being negligible. When this rate is applied to the thickness of the peat as a whole—39 feet—it appears that the elapsed time since peat began to accumulate in this locality is 7800 years. Under prevailing climatic conditions this would be equivalent to the time since deglaciation of the place. As the rate of peat accumulation is not likely to have been as variable as that of delta sediments, this figure is probably more nearly of the correct order of magnitude than figures based on deltas.

Sedimentation on Lake Floors. Many years ago a plan was made (Hotchkiss, 1917) to determine the age of Lake Mendota, Wisconsin, which has been exposed since the Cary subage, but the project was never carried out. Calcareous mud is accumulating on the lake floor, and the plan was to determine (1) the rate of sedimentation by means of pans placed in various parts of the lake, and (2) the thickness of accumulated sediment by core-borings. The physical difficulties of sampling plus the variables that could not be evaluated in the computation make this a hazardous way to try to determine the length of postglacial time. Perhaps it was because of this that the plan was never implemented.

Precipitation of Travertine. Swinnerton (1925) made a preliminary estimate of the time since the deglaciation of Yellow Springs, Greene County, Ohio, in the Tazewell subage, based on the precipitation of travertine at the springs. Assuming that glacial erosion had removed all pre-existing travertine, he divided the volume of existing travertine by the observed annual rate of accumulation, and arrived (tentatively) at 20,000 to 30,000 years.[1] He recognized variations in discharge, solution, rainfall, temperature, and subsurface conduits as important variables. This method may be applicable to other spring deposits. Unfortunately Swinnerton did not publish the details of his computation.

Rate of Radioactive Disintegration of Travertine

Before modern studies of radioactivity as applied to geologic time began, Schlundt and Moore (1909: 33), as an incident in the study of the radioactivity of thermal waters in Yellowstone National Park, attempted to date the radium-bearing travertine of Terrace Mountain. This travertine is one of the earliest deposits at Mammoth Hot Springs, and is overlain by boulders deposited by the latest glacier ice at this locality. They found that this early travertine contains only about 1 per cent of the radium contained in the travertine now being deposited. Assuming that both deposits originally contained the same amount of radium, and that none of the radium content in the earlier deposit had been lost by leaching, and using the best value for the half-time period of radium that was available in 1909, they derived a figure for the age of the early travertine. Using the more recent figure of 1690 years for the half-time period of radium, we may follow

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[1] The time since the Tazewell was estimated by Thornbury (1940) at 45,000 years.

their method and derive an age of 11,200 years for the early travertine.

This method is based on the unproved assumption that the rate of deposition of travertine has been constant throughout the time involved. In addition to this disadvantage, occurences of radium-bearing deposits of Pleistocene date are very rare. Nor can Pleistocene igneous rocks be made use of, because the lead and helium methods of age determination, applicable to rocks of this type, are not applicable to the immediate geologic past. Pleistocene time is so short compared with earlier recognized units of geologic time that it falls within the limits of error of these methods of determination.

Summarizing the results obtained by extrapolation on the rates of various processes, we find that none of them is very satisfactory because all include variable factors that can not be evaluated, and further because, in most cases, the time of inception of the process concerned can not be definitely fixed.

Calculation from Varve Counts

The use of varve counts in the attempt to arrive at the length of postglacial time in any region avoids the necessity of extrapolation because it does not depend on present rates. Instead it makes use of deposits that were laid down during much of the time whose length it is desired to measure.

Origin of Varved Sediments

The glaciated regions in all continents include fine sediments—chiefly clay and silt—laminated in a peculiar way. Ideally the laminae occur in pairs, each pair consisting of a coarse-grained member (chiefly silt) and an overlying fine-grained member (chiefly clay). The coarse member grades up into the fine member but is sharply separated from the fine member of the next underlying pair. Thus it is possible, even in a hand specimen, to determine top and bottom in the layers. The colors of the chief minerals that constitute the silt—quartz and feldspars—are pale; hence the coarse or silt members stand out in contrast with the darker-colored fine or clay members. This gives a clean exposure a striking uniformly banded appearance (Fig. D).

The paired arrangement of the layers early led to the speculation that this character is the result of periodic changes in the conditions of deposition, such as occur with the year's changing seasons (cf. Smith, 1832: 229). Hitchcock, Emerson, Upham, and

Taylor all recognized this relationship, but the detailed study of such deposits has been the work chiefly of Gerard De Geer, beginning in 1882. In 1912 De Geer (1912: 242) proposed to call each pair of layers, which he recognized as annual, a *varve* (Swed. *varv*—a periodic repetition or revolution). Since that time deposits having this paired characteristic have been rather generally called *varved clay*—an inappropriate term in that usually more than half the deposit consists of silt and other particles coarser than clay.

FIG. D.—Exposure of varved clay and silt, South Hadley, Mass. (*R. F. Flint, Connecticut Geol. Survey*).

Johnston (1922: 383) has shown that the varve period in the sediments now being deposited in Lake Louise, Alberta, is the year rather than any larger or smaller division of time, and agreement is now rather general that most of the varves apparent in glacial sediments are in fact annual. The geologic evidence shows that these deposits were laid down on the floors of lakes fed by meltwater from the waning glaciers, mainly though not entirely during the last deglaciation.

The conditions of deposition have been inferred from the geologic evidence and also from the results of laboratory experi-

ments, as, for example, the excellent studies made by Fraser (1929). It is clear that suspended sediments, consisting chiefly of silt and clay, were brought into a temporary glacial lake by streams both from the melting ice and from the surrounding land during the spring and summer seasons. The silt, being heaviest, settled out fairly soon, but the finer clay particles remained in suspension, settling out slowly and gradually during the autumn and winter, when melting had ceased. This gradual separation caused the observed gradation from the coarse member to the fine member of the varve pair. The low temperature of the glacial water was an important factor in delaying the settling of the clay particles. With the resumption of melting in the spring, new sediment began to be poured into the lake, and the coarse fraction of it settled out rapidly on the lake floor, producing the relatively sharp contact between the top of the older varve pair and the base of the younger pair. Thus the varve year commences with the spring.

The salts in seawater prevent the formation of varves of this kind in marine sediments. Being electrolytes, they cause flocculation of the sediment suspended in the water. The sediment is then precipitated as a homogeneous mass of mixed coarse and fine particles, and varves can not form.

The prime condition necessary for varve formation then, is that much of the fine sediment must remain in suspension throughout the spring and summer seasons. This requires that the water must be fresh and cold and that the stream water entering the lake must be lighter than the bulk of the lake water so that it can diffuse over the whole area of the lake. These requirements explain why varves are far better developed in glacial-lake sediments than in lake sediments of nonglacial origin. Undoubtedly therefore the vast majority of the known bodies of varved sediment are the product of glacial meltwater deposits and hence record the near presence of glacier ice where and when they were laid down.

Measurement and Correlation

Acting upon the very probable assumption that the glacial-lake varves exposed in southern and central Sweden represented annual deposits, De Geer (1912) realized that if individual varves could be identified in two or more localities, they might be correlated throughout a broad region and used as a measure of time. On this basis he began studies in 1904 which led, 34 years later, to the publication of a vast definitive report on his results (De Geer, 1940).

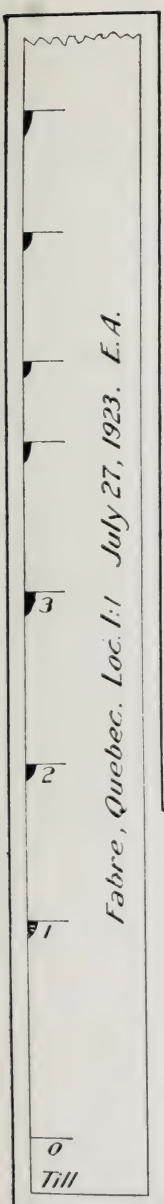

FIG. E.—Method of measuring varves on a strip of paper (Antevs).

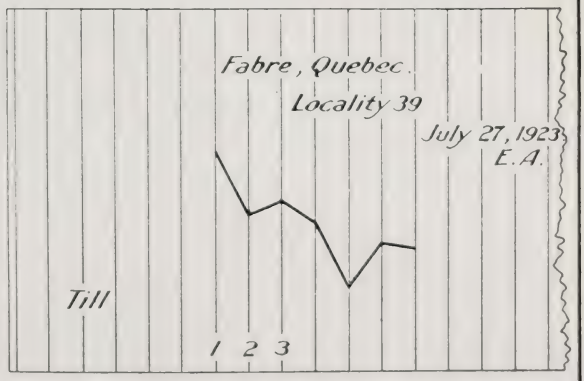

FIG. F.—Curve representing thicknesses of 7 successive varves, constructed from paper strip (left) that had been marked in the field as in Fig. E. (Antevs, Geol. Surv. of Canada).

De Geer's correlations are based fundamentally on variations in thickness of individual varves. Vertical exposures of varved sediments in clay pits, river bluffs, and other excavations are cleaned to smoothness with spade and trowel, and sections disturbed or contorted by sliding or other agencies are avoided, if possible. The top and base of each varve, and the position of the gradational contact between the coarse member and the fine member, are marked off on a narrow strip of paper held vertically (Fig. E).

These field measurements are later plotted as curves on graph paper, the number of varves in the measured section being plotted against the thickness of each varve (Fig. F). Two curves constructed in this way from exposures in different localities are then placed side by side and one is moved up or down with respect to the other until, by this process of trial and error, a good fit or match is obtained (Fig. G). Then, if Varve 23 at Locality A is considered to match Varve 56 at Locality B, these are taken to represent the same year, and a composite chronology applying to these two localities and to the area between them is considered to be established. Varve 71 at Locality B may be found by this method to match Varve 3 at Locality C, and the composite correlation—and thereby also the chronology—is thus extended further.

This correlation based on varve thickness rests upon the assumption that during the episode of deposition the weather varied from year to year and that the weather characteristics of any year (especially the summer season) were reflected, through the

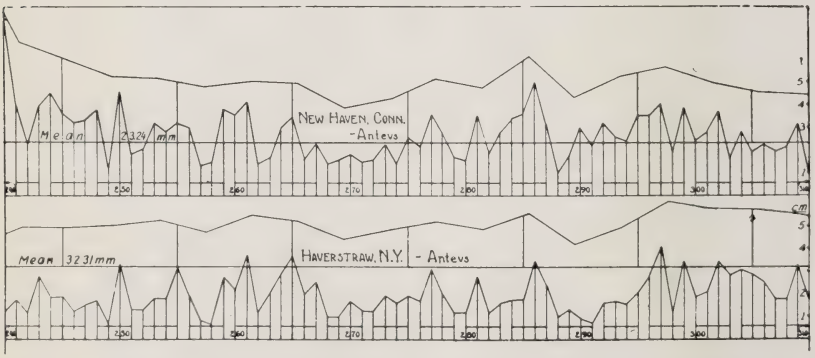

FIG. G.—Curves constructed from 70 consecutive varves measured at New Haven, Connecticut (above) and from 70 varves measured at Haverstraw, New York (below). The two curves have been placed in the position in which they are believed to correspond. (Reeds).

amount of glacier ice melted, in the amount of sediment deposited in the glacial lake or lakes throughout a region whose width equals the distance between the two mutually most distant localities in which the same single varve is recognized.

De Geer early found empirically that between curves obtained from localities only 2/3 mile apart he could usually get good fits. Hence he felt confidence in extending his measurements through a distance of about 600 miles, from Scania, in southeastern Sweden, to Ragunda, in central Sweden, the measurements being, as nearly as practicable, 2/3 mile apart. He found that individual varves could be recognized in the curves through distances up to 35 miles, and that the varves lapped off upon each other like shingles on a roof, extending progressively farther north with increasing height in the section. When this work was completed and extended still farther southward, De Geer and his students had compiled a chronology, which, based on De Geer's correlations of the curves obtained, embraced about 8000 years as the time involved in the retreat of the margin of the Scandinavian ice sheet from the southern tip of Sweden to Ragunda and the deposition of lacustrine silt and clay (De Geer, 1929: 689).

To this Lidén added a later, so-called postglacial period of about 8700 years, but even so he did not succeed in connecting this with historic time.

The sequence of varves as worked out by De Geer and his students is not continuous; there are gaps in it across which the chronology was interpolated on a basis of inferences drawn from related eskers (De Geer, 1912: 248).

De Geer also attempted to work out the *rate* of deglaciation by determining the headward limit of each overlapping varve. In order to do this it is necessary that the bottom varve in each measured section be exposed. According to De Geer most of the 700 closely spaced exposures in the Stockholm district reached the bottom varve, and from them a rate of retreat of several hundred feet per year was inferred. Farther north the rate is thought to have increased, but throughout the Swedish record it is believed to have been of this general order of magnitude.

Later Antevs (1922, 1925, 1928, 1931) applied the method of varve measurement to the glacial-lake sediments of eastern North America. Owing to the presence of serious gaps in the record, his first conclusion (1922: 48) was that "the time elapsed since the ice sheet disappeared from New England cannot even be esti-

mated with any claim to accuracy." Later (1928: 155, 168) he estimated the time involved in the shrinkage of the Wisconsin ice-sheet margin from Long Island to Cochrane, Ontario (about midway between the Great Lakes and Hudson Bay) at about 28,000 years, and the time from the Long Island position to the present at 40,000 (±10,000) years.[2] Of this total number of years, about 19,000 years are based on varve measurements; the remainder are interpolated, principally across three gaps. These are: Long Island to Hartford, Connecticut: about 50 miles; St. Johnsbury, Vermont, to Stony Lake, Ontario: about 120 miles; Mattawa, Ontario, to Lake Timiskaming, Ontario: about 170 miles. In addition, at Claremont, New Hampshire, there is another gap which Antevs (1922: 83) assumed amounted to 200 or 300 varve.

During the progress of Antevs' work in North America, De Geer extended his varve analysis to include the correlation of varve curves from localities far from each other. He correlated curves, for example, between Sweden and North America and between Sweden and South America, inferring that the same groups of years are identifiable on these pairs of curves, and that thus an absolute intercontinental correlation is created.

A varve is a stratigraphic unit, and like other stratigraphic units it can be followed throughout its extent only if its exposure is continuous. The normal procedure of tracing a layer of bedrock between exposures involves the use of some distinctive recognizable character in either the lithology or the fossil content of the stratum. But a given clay-silt varve is likely to differ from those immediately above and below it, if it differs at all, only in its thickness. Furthermore, the absolute thickness of a varve decreases away from the source of sedimentation; hence the distinctive character, if any, of a varve is not absolute thickness but relative thickness. In order to identify a given varve in two different exposures, one near and the other far from the source of supply, it must be assumed that the relative thickness of all the varves in the section remains the same; in other words, that each varve thickens headward at a proportional rate. Further, in districts where the surface beneath the varved sediments is sharply irregular, the thickness of a single varve may be extremely variable, thinning on steep slopes and thickening on gentle ones. This is the case in the Stockholm district, but because the exposures there are very close together De Geer (1934:2) felt great confidence in his corre-

[2] Elaborately recalculated by Bryan and Ray (1940: 58-67).

lation despite the variations he had to deal with. His method in such cases was to use the thickness variations of distinctive groups of varves rather than of individual varves, although, as he admitted, the groups as such are not everywhere normally developed (De Geer, 1934:13).

Few would doubt their own ability to correlate two varve curves from exposures, say, 200 yards apart in a single body of sediment, allowing their results to be checked by artificial completion of the exposure across the intervening distance to prove the correctness of the correlation by continuous tracing. If on the other hand, many have doubted the validity of De Geer's intercontinental correlations involving pairs of localities many thousands of miles apart (cf. Brückner, 1921; Antevs, 1922: 48; 1931: 35; Reeds, 1929: 624; Ellsworth and Wilgus, 1930; Coleman, 1941: 86, 153). The question of the reliability of varves as correlation units is therefore largely the question: through how great a distance can two varve curves be correlated with confidence? At present, different persons experienced in varve study give different answers to this question. De Geer goes farthest in connecting curves through great distances. An excellent critical appraisal of his method of intercontinental correlation is given by Antevs (1931: 34-41) who concludes that it is unreliable. An interesting reply has been made by De Geer (1934).

Antevs' point of view is more conservative than that of De Geer. He says (Antevs, 1931: 36):

> "Agreement between curves is determined by the trend of lines connecting points denoting, in this case, the thickness of the annual deposit. The transportation and sedimentation of mud in a glacial lake being influenced by a number of conditions, such as shape of the basin, islands, currents, and the chemical and physical properties of the glacial mud and of the lake water, a perfect agreement cannot be expected between varve graphs. The degree of correspondence that shall be deemed necessary for correlation is, therefore, left to the correlator's discretion. Because there is no simple way to determine or objectively to estimate the degree of actual correspondence between two graphs, it follows that the appreciation of the similarity is also subject to personal judgment. Varve graphs are individually only moderately distinctive, and, in addition, being records of the summer heat, they present periodic, more or less similar fluctuations.
>
> "These conditions make it necessary to exercise considerable conservatism in assuming varve correlations. Correlations cannot be made on agreement of curves alone. It is necessary to know from striae, moraines, eskers, drumlins, and other features, that the compared varve series are of approximately the same age."

Sauramo (1923: 11) is even more conservative than Antevs. He states that correlation based exclusively on varve thickness may lead to unreliable results, for three reasons:

1. In many sections the variation in thickness of adjacent varves is so small that the curve constructed from them approaches a straight line and precludes correlation.

2. Thicknesses commonly vary in a horizontal direction so that the same sequence of varves appears different in curves from two or more localities; hence correlation can not be made. This occurs very commonly, and may be true for two localities very close together, as Sauramo shows. On the other hand, he agrees (Sauramo, 1929: 41, 52) that under favorable conditions individual varves maintain their thicknesses relative to each other, and hence can be correlated from place to place.

3. Correlations based on the matching of two curves by this method have been shown, on a basis of the stratigraphic relations of the sedimentary bodies concerned, to be wholly erroneous (cf. Sauramo, 1918: 34).

Sauramo might also properly have indicated that there is disagreement or uncertainty in some localities as to whether the measured units are of annual or lesser value (cf. Antevs, 1931: 31; Fraser, 1929; Speight, 1926: 71).

In consequence, Sauramo studies varves as the stratigrapher studies layers of rock devoid of fossils: he makes a sedimentologic and stratigraphic study, groups the individual varves into varve series, recognizes key horizons on a basis of color, grainsize, and other physical properties, and notes facies changes. He makes no attempt to correlate individual varves until the varve series have been identified. He says (Sauramo, 1923: 13):

> "By thus making *first* the correlation of *larger*, and then of *successively smaller* units of sedimentation, the probability of error is reduced as far as possible. Each connection is checked from several sides, being based upon not one but several characters which are in part independent of each other. It is then always possible to tell whether the connection has reached the accuracy of single varves or whether the possible error remains larger, and how large it is. Connection based upon variation in thickness only affords no check of this kind, and the amount of possible error can not be estimated at all."

The whole matter of the reliability and usefulness of varve correlation is at present in an unsatisfactory state. Largely because it has been subjected to an inadequate amount of criticism and discussion, most geologists have no definite opinions on it.

Nor are they likely to have opinions of value until varve correlation has been objectively tested by a number of investigators working independently on the same exposures. As Antevs points out, correlation is to some extent a matter of judgment. The extent to which judgment plays a part is capable of objective testing, and until these tests are applied, varve study is not likely to progress far beyond its present state. Meanwhile no one familiar with varve literature can fail to be impressed by the half century of tedious groundwork accomplished by De Geer and his helpers, nor by the enthusiasm with which varve studies have been carried on.

GLACIAL AND INTERGLACIAL CHRONOLOGY

A few attempts have been made to estimate the lengths of various glacial and interglacial subdivisions of the Pleistocence Epoch. All but one of them are based on comparison of the progress reached by some process, such as weathering or general erosion, during some stratigraphically known time, with the progress reached by the same process in postglacial time within the same region. Assuming an absolute value for postglacial time, they are thus able to convert the estimate into absolute terms. We have seen, however, that the absolute duration of postglacial time has not been determined for any region with even an approach to accuracy; in consequence the estimates of earlier Pleistocene time units include this inaccuracy as well as others inherent in the bases used for the estimates. If the values estimated for postglacial time are at least of the right order of magnitude, then perhaps the same can be said of the more successful estimates for the earlier times, but as all of them are largely matters of judgment, the reader must form his own opinion of the merits of each from the brief summaries that can be given here and from the original studies on which the summaries are based.

Inference from Degree of Weathering

Pedestals Beneath Erratic Boulders

Matthes (1930: 70-72) has estimated the time since the El Portal glaciation in Yosemite National Park, California, tentatively correlated with the Illinoian glaciation, in the following manner: The summit of Moraine Dome was glaciated during the El Portal glacial age but not during the Wisconsin glacial age. On this summit a glacial boulder is perched on a pedestal 7 feet high and 4 feet thick. The pedestal consists of the remains of an aplite dike which, being resistant to weathering, has developed the pedestal

while the surrounding quartz monzonite, a weaker rock type, has disintegrated. As the dike-pedestal is too thin and delicate to have withstood glaciation, it must entirely postdate the El Portal age. In contrast, the same kinds of rocks in this vicinity that were glacially smoothed during the Wisconsin age are so fresh that they show hardly any weathering at all. Hence the El Portal glaciation is estimated to be 10 to 20 times as remote in time as the Wisconsin glaciation. On the assumption that the freshly glaciated rock surfaces in this vicinity were abandoned by the Wisconsin ice 10,000 years ago, the end of the El Portal (=Illinoian?) glacial age here would then be placed at 100,000 to 200,000 years ago.

This estimate makes no pretense to accuracy but on the facts given it probably does represent the order of magnitude of the elapsed time since the earlier glaciation.

Decomposition of Pleistocene Sediments

Depth of leaching in Iowa. A body of drift begins to be decomposed by atmospheric agencies, aided by subsurface water, as soon as it is exposed. After decomposition has progressed for a long time, it produces a zonation of the drift (whether till, gravel, or other material) as follows:

Surficial soil
Chemically decomposed till, consisting chiefly of alteration products and of the most resistant constituents of the original drift
Leached and oxidized drift
Oxidized drift
Unaltered drift

The arrangement of these zones shows that, as might be expected, oxidation progresses more rapidly than leaching, and that leaching takes place more rapidly than thoroughgoing decomposition of the drift.

By examining a very large number of drift sections in Iowa, Kay (1931) found that the "depth of leaching"—that is, the distance from the surface down to the base of the leached and oxidized zone—is very nearly uniform on any given drift sheet regardless of whether the material consists of till, or gravel, or loess, or any combination of them, provided only that the sections measured are situated on broad interfluves with very little slope. He reasoned that depth of leaching is a fairly good indicator of the time during which decomposition was in progress. Where a drift sheet is overlain by another drift sheet, this time is equal only to the length of the intervening interglacial interval; where no such cover exists, the time of decomposition runs right up to the present.

Kay found that in the Mankato drift the average depth of leaching is 2.5 feet, whereas in the Iowan drift, where not covered by later deposits, it is 5.5 feet or 2.2 times the depth in the Mankato. Assuming post-Mankato time in Iowa to equal 25,000 years, he multiplied this figure by 2.2 in order to obtain an estimate for post-Iowan time. Applying this method to the earlier drift sheets, he derived figures that may be summarized as follows:

Type of Material	*Stratigraphic position*	*Depth of leaching, feet*	*Factor*	*Result, years*	
Gravel	Wisconsin (Mankato)	2.5		25,000	(assumed)
Gravel	Iowan (never covered by younger deposits)	5.5	2.2	55,000	(measures all post-Iowan time)
Till	Illinoian (where covered by Iowan drift)	12.0	4.8	120,000	(measures Sangamon interglacial age)
Till	Kansan (where covered by Illinoian drift)	30.0	12.0	300,000	(measures Yarmouth interglacial age)
Till	Nebraskan (where covered by Kansan drift)	20.0	8.0	200,000	(measures Aftonian interglacial age)

The absolute value of these figures depends on the initial assumption as to the length of post-Mankato time. Their relative value depends to some extent on whether or not the rate of leaching is a straight-line function of depth—at least down to a depth of 30 feet—a factor carefully noted by Kay. If this is not the case, then the absolute value of each result must be increased, perhaps greatly, and the relative values of the group will differ from those given.

The combined lengths of the three recognized interglacial ages, plus all of post-Iowan time, according to these estimates total 675,000 years. But this figure does not include the Nebraskan, Kansan, and Illinoian glacial ages, nor the Iowan subage of the Wisconsin age, there being no comparable basis for estimating the lengths of these units.

Dept of leaching in Indiana. Thornbury (1940) has made similar estimates for drifts in Indiana, following in general the method used by Kay. Assuming a value of 25,000 years for post-Mankato

time, he estimated the Cary-Mankato interval at 10,000 years, and the Tazewell-Cary interval at 10,000 years, making the values of post-Cary and Post-Tazewell time 35,000 years and 45,000 years respectively. He found the depth of leaching of Illinoian drift in Indiana, where covered by Wisconsin drift, to be only 6 feet, whereas Kay had found this depth to be 12 feet in Iowa. Thornbury attributes the difference to lower relief and poorer drainage in Indiana than in Iowa, during Sangamon time. However, by using the rate of formation of gumbotil (estimated at 1 foot in 19,000 years following an initial period of 50,000 years during which no gumbotil forms) instead of depth of leaching, Thornbury (1940: 473-474) estimates that Sangamon time endured 135,000 years, as against Kay's estimate of 120,000 years based on depth of leaching. Both methods, of course, are based ultimately on an assumed value of 25,000 years for post-Mankato time.

Thicknesses of Residual Soils in Bermuda. The stratigraphy of the island of Bermuda consists chiefly of calcareous eolianite (limestones originally deposited by the wind), alternating with red and brown clay soils. Each of the soil layers is the product of protracted chemical decay of the eolianite that underlies it, and in each case the decay took place before the next overlying eolianite was deposited. The eolianites are believed to have been accumulated during the glacial ages, when sea level was low, and when winds were strong owing to displacement of the polar-front zone toward the south. The soil-making times are thought to have coincided with the interglacials, when sea level was high and when winds were gentler, like those of today. The use of these soils in an attempt to calculate the values of Pleistocene time units we owe to Sayles (1931: 452-456). Sayles starts with the assumption of Kay, already referred to, that "postglacial" (actually post-Mankato) time has endured 25,000 years. As the soil now forming on flat surfaces on the stratigraphically highest eolianite in Bermuda is approximately 6 inches thick, and as this soil is believed to postdate the last glaciation (though no attempt is made to define its relation to the Wisconsin subages recognized in North America), it is inferred that the time required to create one foot of soil on a flat surface is 50,000 years. (Incidentally, one cubic foot of soil is calculated to require the solution of 100 cubic feet of eolianite). Applying this figure to the measured thicknesses of the various soil layers, Sayles gets the following figures:

Soil	*Thickness feet*	*Estimated period of development, years*	*Suggested correlation with North America*
Soil now forming Eolianite	0.5	25,000 (assumed)	
McGall's soil [1] Eolianite		10,000 ?	Wisconsin
Signal Hill soil [1] Eolianite		10,000 ?	
St. George's soil Eolianite	2.0	120,000	Sangamon Illinoian
Harrington soil	2.0	250,000	Yarmouth
Marine limestone [1]			
Shore hills soil	2.0		
Marine limestone [2] Eolianite			

[1] Found exposed on slopes only; probably developed rapidly, in part by slopewash.

[2] These layers necessarily represent high sealevels and hence are referable to interglacial rather than glacial times.

This calculation encounters the same fundamental difficulty that Kay encountered: the basic figure, 25,000 years, has to be assumed. However, the relative magnitudes of the figures are significant, especially when compared with the figures derived by Kay. The importance of determining with accuracy the length of postglacial time for each of several regions becomes more and more obvious, although for Bermuda this would be difficult because, even on the assumption that the eolianites record low sealevels and the soils high ones, there is as yet no means of correlating the beginning of formation of the modern soil in Bermuda with any particular event recorded by the stratigraphy of North America.

Inference from Degree of Erosional Loss

An estimate based on the degree of erosional loss by the several drift sheets in the Mississippi basin has been attempted by Leverett (1930). He too began with the assumption that post-Mankato time has lasted 25,000 to 30,000 years. Using this as a basis he guessed that all of post-Tazewell time must be about 70,000 years long.

Leverett then estimated the average thickness of the prism of drift that has been removed from each of four drift sheets in districts where they have not been covered by younger deposits. Using as a basis his guess at the length of post-Tazewell time, he then calculated the lengths of post-Illinoian and post-Kansan time, as follows:

Stratigraphic unit	*Erosional loss, feet*	*Time since uncovered by the ice*
Tazewell	5	70,000 (assumed)
Illinoian	15	210,000
Kansan	50	700,000

Comparison of the figures with those arrived at by Kay and by Thornbury shows that Leverett's post-Tazewell figure is 25,000 years longer than Thornbury's, and 15,000 years longer than Kay's estimate for the whole of post-Iowan time. If we use Thornbury's estimate of 45,000 years for post-Tazewell time, and follow Leverett's method, we get 135,000 years for all of post-Illinoian time, whereas Thornbury gets 135,000 years for the duration of the Sangamon age alone. Both methods use the same (assumed) yardstick, namely, 25,000 years for post-Mankato time; hence the discrepancy lies in the difference between comparative depth of leaching and comparative degree of erosional loss. The former should be the more reliable because it is subject to fewer variable influences and also because it is less difficult to measure accurately. Leverett's unparalleled experience in the observation of drifts undoubtedly enabled him to estimate their erosional losses more closely than anyone else, but the fact remains that the losses had to be estimated because they could not be measured.

Holmes (1935) has described an interglacial valley at Chittenango Falls State Park in central New York. The valley was filled with drift during the latest glaciation of the region, and has since been partly re-excavated. The interglacial valley itself is 8.5 times as long as the postglacial excavation. Holmes assumes the duration of postglacial time here to have been 20,000 years, and assumes further that the rates of lengthening of the two cuts were comparable. Thus he arrives at 170,000 years as the time required for the cutting of the interglacial valley. The method is necessarily crude but gives results of an order of magnitude comparable with those inferred from the gumbotils.

Deduction from Astronomic Relations of Earth to Sun

If the climatic changes responsible for the glacial and interglacial ages were proved to be controlled by astronomic changes that are periodic, the periods of the changes being known, then it would be possible to date accurately the principal glacial and interglacial events. Three periodic or near-periodic changes in the elements of the Earth's orbit are indeed known. These affect

(1) the eccentricity of the orbit, with a period of about 91,800 years;

(2) the angle between the Earth's axis and the plane of the of the ecliptic, with a period of a little more than 40,000 years;

(3) the shifting of the perihelion (causing precession of the equinoxes), with a period of slightly more than 21,000 years.

Each of these changes affects the amount of solar radiation received by any given part of the Earth throughout its period. When the three kinds of changes are combined, instead of being considered separately, it becomes possible to construct for any latitude a curve showing the amount of solar heat received throughout a long period of time.

Milutin Milankovitch (1920; see also the revised curve in Milankovitch, 1930) calculated such a curve for Latitudes 55°, 60°, and 65° North, using 176 dates as control points, and considering only the summer months, because summer temperatures are more critical for glacial fluctuations than winter temperature. The curve (Fig. H) is of course irregular, because it combines three different influences each having a different period.

The curve shows nine conspicuous radiation minima arranged in four groups of two or three minima each. These four groups are regarded by some authorities as representing the four glacial ages recognized in the region of the Alps by Penck and Brückner, and the two or three minima within each group are compared even more closely with elements in the geologic record, by some who profess to see in the curve a fairly complete and accurate picture of the climatic changes of the Pleistocene epoch (*cf.* especially Soergel, 1937; Zeuner, 1935).

On the assumption that the Milankovitch curve actually represents the geologic record, the absolute date of any major glacial or interglacial event can be fixed by deduction from the curve. The following table, greatly modified from Zeuner (1935, p. 357), shows the dates of major events as thus interpreted:

Stratigraphic subdivision	*Date of maximum (years before 1800 A. D.)*
Würm 3 (= Pomeranian)	18,000
Würm 2 (= Weichsel)	67,000
Würm 1 (= Warthe)	112,000
Riss/Würm Interglacial	143,000
Riss 2 (= Saale)	183,000
Riss 1	226,000
Mindel/Riss Interglacial	
Mindel 2 (= Elster)	430,000
Mindel 1	472,000
Günz/Mindel Interglacial	
Günz 2	545,000
Günz 1	586,000

The objections to this plausible scheme are several, and are astronomic, geologic, and climatologic in scope. The prime astronomic objection (which may indeed prove groundless when the facts are better known) concerns the accuracy of the computations. These, although perhaps generally reliable for the later parts of the time in question, may be inaccurate for times more than half a million years distant (*cf.* Brouwer, quoted in Schulman, 1938). Another astronomic objection lies in the fact that the three astronomic changes employed in constructing the curve include two factors that produce exact alternations between the northern and southern hemispheres, and one factor (variations in the ellipticity of the Earth's orbit) that is temporarily coincident in the two hemispheres. The combined effect of the three factors is to produce radiation minima that are not contemporaneous in these two hemispheres. The minima for the southern hemisphere do not coincide with the maxima for the northern; on the contrary the relationship is irregular, with temporal offsets of various lengths. The curve calculated for the southern hemisphere (Köppen and Wegener, 1924: 256) ought to be compared with the South American glacial record, in order that the amount of agreement may be checked.

The principal objection to the scheme from the geologic point of view is that the deduced interglacial times do not appear to be long enough to have produced the observed amounts of decomposition of the drift sheets. The extent of agreement between the curve and the geologic evidence from North America is less than that for Europe in general and for the Alps in particular. No attempt at detailed North American comparisons seems to have been made. Perhaps this is because American glacial geologists

have been more skeptical of the scheme and of its basis than have many Europeans, although Antevs (1938) has used the scheme in tentatively dating North American events. On the other hand we must admit that the nature of the geologic evidence in any part of the world is necessarily far from precise, and that close comparison with any mathematical curve is therefore very difficult to make.

From the climatologic viewpoint, a difficulty with the scheme based on the Milankovitch curve is that it fails to consider any factor other than solar radiation, despite the proved close relationship between glaciation and the distribution of land and sea (cf. Brooks, 1928: 117-119). Furthermore, climatologists are not agreed that radiation minima, regardless of their causes, must coincide with glacial (*cf.* Simpson, 1934).

Other schemes somewhat similar to that of Milankovitch have been put forth by Spitaler (1921) and by Köppen and Wegener (1924). The same general objections apply to them, and they are not discussed here.

Inference from Concentration of Radium in Sea-Floor Sediments

The most recent contribution to the determination of an absolute chronology of Pleistocene events is the work of Piggot and Urry (1942) on the concentrations of radium in sea-floor sediments. The helium and lead methods used for rocks of greater age are not applicable to the determination of dates as recent as the Pleistocene. However, these investigators have used radio-elements in an entirely different way. They have found that the content of radium in marine sediments varies with time in a certain definite way, and have established a standard curve of radium concentration plotted against time. By comparison with this curve the age of a layer of sediment (that is, the elapsed time since its deposition) can be determined. Unfortunately the radium content becomes essentially constant after 300,000 to 400,000 years. Hence the method is of use only for times within this limit, and is not applicable to the whole of the Pleistocene epoch.

Thus far the radium-concentration method has been applied only to cores taken from the North Atlantic sea floor, where, however, its accuracy has been checked and found satisfactory by reference to a "key horizon"—a distinctive layer of volcanic ash recognizable in the cores. The potential value of this method for dating events during at least a part of the Pleistocene is great.

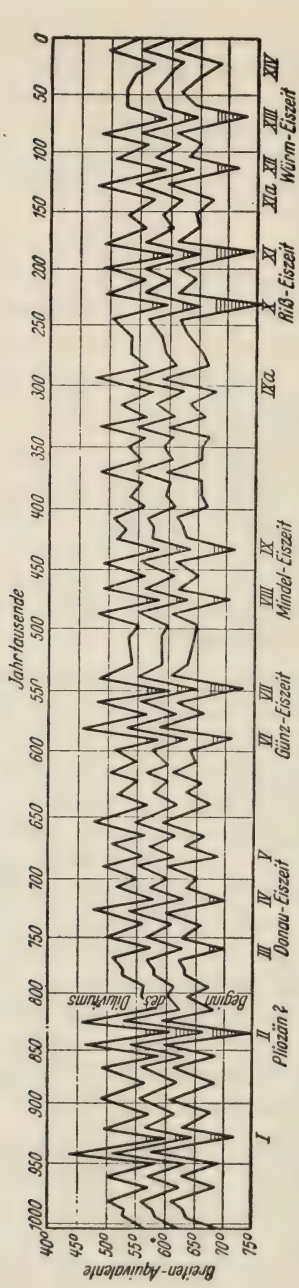

FIG. H.—Curves showing deduced variations in solar radiation received at 55°, 60°, and 65° North Latitude during the summers of the one million years preceding 1800 A. D. Horizontal scale=units of 50,000 years. Vertical scale=latitude in 5-degree units. Thus "latitude-equivalents"—imaginary changes of latitude—are shown in place of changes in the actual amount of radiation received at one latitude. (Milankovitch).

SUMMARY

Examination of the data on glacial and interglacial chronology reveals the fact that absolute dating of Pleistocene events has not yet been accomplished. Most of the methods used for dating glacial and interglacial events use as a baseline a postglacial span of time that has to be assumed. Much ingenuity has been expended on the problem, but the problem still remains unsolved. It is possible that the best estimates of postglacial time for any region are of the right order of magnitude, but as we go farther back into the Pleistocene, the lengths of time involved become rapidly more uncertain. The length of the whole Pleistocene epoch appears to be not less than one million years; it is probably not more than five million years. We may well doubt that data we have been able to gather thus far justify any closer approximation. On the other hand, studies of radium concentration in sea-floor sediments may lead to the establishment of a satisfactory chronology of the last 300,000 years.

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THE CONFEDERATE STATES OF AMERICA: AN ESSAY IN INTERNATIONAL ORGANIZATION

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More than any other nation probably, the American people have had actual experience with the problems of international organization. Because I believe that history is a valuable methodology for political science, I have thought it practicable to observe the results of our previous experimentation. Since it now appears that the United States is definitely committed to participation in world affairs, I trust that we may deduce from the past certain postulates of current significance. In our history we have tried and tested three somewhat different types of union: the Articles of Confederation (1781 to 1789), the Constitution of the Confederate States of America (1861 to 1865), and the Constitution of the United States (1789 to the present date).

All of us are presumed to know something about the Constitution of the United States. Most of us know a little about the Articles of Confederation, since it is conventional for textbook writers in American government and American history to include several paragraphs outlining the weaknesses of the Articles as due explanation for the decisions made in the Convention of 1787. Few of us, however, except professors of southern history, know anything about the Constitution of the Confederacy. Even in the South, where there is considerable nostalgia for the Lost Cause, there is a surprising paucity of specific information. Therefore I have chosen to survey the ante-bellum southern historical and legal interpretation of our federal union, and at the same time to trace the development of the Confederate States of America as an essay in international organization.

For more than seventy years following the Constitutional Convention of Philadelphia in 1787, the school of Jefferson and Calhoun taught that the American Constitutional system was created, and should, therefore, be maintained according to the principles of international organization. Wherefrom, the South developed a historical argument and a political theory of the formation of the Federal Union based mainly on concepts of international law.

The Southern interpretation of early American political history rests on the proposition that the "States were not created by the government of the Union, but antedated and created that organ-

ism . . .''[1] During the colonial period, the inhabitants of one colony owed no obedience to the laws and were not under the jurisdiction of any other colony, were under no civil obligation to bear arms or pay taxes or in any way to contribute to the support or defense of one another, but were wholly distinct and separate in political functions, rights and duties. The Continental Congresses claimed no sovereign authority, and seldom assumed to go beyond deliberation and recommendation. Members of the Congress were delegates of the colonists and not representatives of the people. The procedure in the Continental Congresses was based on the equality of the colonies; each colony had one vote, irrespective of the size of the several delegations; and any one colony could secure the postponement of discussion on any question.

The Declaration of Independence in 1776, legally severing the ties with Great Britain, made each colony a sovereign and independent State. The Declaration of July Fourth was made in the name of thirteen States, although, as a matter of historical record, several of the States had already made their own declarations of independence and had commenced hostilities against Great Britain. Thus the Constitutions of the original States, which preceded the Articles of Confederation, were formed by virtue of the sovereign and independent character of the States.

The Thirteen States entered into ''perpetual union'' in 1781, after each State had separately ratified the Articles of Confederation. The status of each State in the Union was specifically defined in Article II: *''Each State retains its sovereignty, freedom and independence, and every power, jurisdiction and right, which is not by this confederation expressly delegated to the United States, in Congress assembled.''* The nature of the Union was described in Article III. *''The said States hereby severally enter into a firm league of friendship with each other, for their common defense, the security of their liberties, and their mutual and general welfare.''*

The Constitutional Convention at Philadelphia in 1787 resembled an international conference both in form and procedure. The delegates were appointed by the States; all voting was by the States; and each State had one vote. Ratification was by constituent assemblies called by the governments in the several States. The ratification of one State was in no wise binding upon any other State. If Rhode Island had preferred to maintain her sovereignty and had continued to refuse ratification, Rhode Island

[1] J. L. M. Curry, *Civil History of the Government of the Confederate States.* (Richmond, 1901), p. 200.

might have remained as independent as France or England or any other foreign power.[2]

This then is the conventional southern interpretation of the making of the Federal Union. It has an important bearing on Southerners' legal understanding of the Federal Constitution. Thus John Taylor of Caroline always claimed that he could read no intention of an American Nation in the original phraseology of the Constitution. He simply regarded the Constitution as a treaty among the States, subject to alteration by the original parties. St. George Tucker, in his *Commentaries on Blackstone*, added legal prestige to this argument; confounding natural rights and state rights, he declared the States had the same right to withdraw from an oppressive common government as the individual to resist and overthrow a tyrannical government. Just as the colonists asserted the right of revolution, so could the States claim the right of secession.

According to the southern legalists, then, the Constitution of 1787 with all its subsequent amendments was no more than a compact between distinct and sovereign States. The Federal Government possessed no inherent powers, but only those powers which were specifically enumerated in the Constitution. Sovereignty continued to reside in the States. The States did not surrender any of their powers to the Federal Government, but mutually agreed to abstain from their exercise themselves, and to confer this exercise on a common agent for the better security of the great objects of the union as set forth in the preamble. Such a delegation of powers, by voluntary engagement, could scarcely be construed as a detraction of sovereignty from the States.[3]

The early Southern theorists were much taken with Vattel's definition of a *federal republic* and quoted it frequently to illustrate their own views as to the nature of the Federal Union:

> Several sovereign and independent States may unite themselves together by a perpetual confederacy without each in particular ceasing to be a perfect State. They will form together a *federal republic:* the deliberations in common will offer no violence to the sovereignty of each member, though they may, in certain respects, put some restraint on the exercise of it, in virtue of voluntary engagements. A person does not cease to be free and independent

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[2] It would appear that the southern historians rather scanted the actual spirit of the Convention. The Randolph Resolutions which were the basis of discussion favored the establishment of a "national government," and Randolph himself candidly confessed that he meant a "strong consolidated union in which the idea of States should be nearly annihilated."

[3] A. Stephens, *Constitutional View of the War Between the States* (1870), Vol. 2, Colloquy 13.

> when he is obliged to fulfill the engagements into which he has very willingly entered.[4]

Jefferson Davis, speaking of the Confederate Fathers, writes "Their ideas were in entire accord with those of Vattel."[5] Alexander Stephens uses the same passage in his *Constitutional View*, concluding, "That, I maintain, was exactly what the States of our Union did by the adoption of the Constitution."[6]

On the nature of the Federal Union under this constitutional compact, Stephens is most explicit: "The States collectively constitute an international unit as regards third parties, but do not cease to be international units as regards each other . . . The United States is not a Nation of individuals blended in a common mass, with a consolidated sovereignty over the whole, but a nation, the constituent elements or members of which are separate and distinct political organizations, States or Sovereignties . . . a Nation of Nations."[7]

This "international" version of the American Union was also the rationalization and justification of the secession of the Southern States in 1860-1861.[8] The historians shrewdly pointed to the original terms of the ratification of the Constitution, wherein some of the States, notably New York, Rhode Island and Virginia, had mentioned the future contingency of reassumption of sovereignty. The political theorists explained that it was unnecessary for the Constitution to affirm the right of secession, since that was an obvious attribute of sovereignty and, as such, reserved to the States. The legalists argued that, while in partnerships between men, or in treaties between governments, it is unusual to make provision for the dissolution of the agreement unless there be a special reason for a limitation of time, it is nevertheless clearly understood that either of the contracting parties may withdraw from the compact

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[4] Vattel, *Law of Nations*, Bk. 1, ch. 1, sec. 10. Confederate literature has frequent reference to Vattel on Sovereignty, Federalism, etc. The "Fathers" of the Confederate Constitution presumably used Vattel's terminology in the original text of the Constitution; the Committee on Permanent Government used *federal republic* until the last draft, where it is replaced by *Confederate States of America*.

[5] Jefferson Davis, *Rise and Fall of the Confederate Government* (1881), vol. 1, p. 70.

[6] Stephens, vol. 1, p. 70.

[7] Stephens, vol. 2, pp. 19, 20.

[8] It is not intended to imply, of course, that the cause of the War between the States was legal or even political. The basic cause was economic: an agricultural minority resenting the encroachments of an expanding industrial majority.

provided that the rights of the other parties are not thereby damaged.[9]

The "international" argument for secession was ably represented by Hemphill of Texas to the United States Senate. He expounded the right of secession as dependent entirely on international law, "*above and independent of the Constitution*":

> "The States, and they alone, being parties to the Constitution, it is as between them a compact, or league, although it is a frame of government for those upon whom it operates: and the States being sovereign members of this league, or confederacy, have a right, as stable as the foundations of international law, to renounce the league at any time, and withdraw from the federation."

The Southern States did not withdraw from the federal union by concerted action. The acts of secession were by the respective constituent authorities in the States, each State separately dissolving the connections with the United States.[10] The ordinances of secession were all carefully worded to make clear in each case that the seceding State was reassuming its free, sovereign and independent character. The several State governments in the period between Secession and Confederation attempted to carry on under the presumption of restored sovereignty and independence. Those powers which had previously been delegated to the federal government, particularly the military and postal powers, were taken over by the State governments, which were each hastily reorganized to meet the new demands in functions.[11]

The Confederate States of America was initiated through diplomatic negotiations among the seceding States. The secession con-

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[9] Stephens, vol. 1, p. 495: "Now as to the rightfulness of the State's thus resuming her sovereign powers . . . In answer to your question, whether she could do this without a breach of her solemn obligations, under the Compact, I give this full and direct answer: she had a perfect right so to do, subject to no authority, but the great moral law which governs the intercourse between Independent, Sovereign, Powers, Peoples, or Nations. Her action was subject to the authority of that law and none other. It is the inherent right of Nations, subject to this law alone to disregard the obligations of compacts of all sorts, by declaring themselves no longer bound in any way by them."

[10]

South Carolina	Dec. 20, 1860	Alabama	Jan. 11, 1861
Florida	Jan. 11, 1861	Mississippi	Jan. 11, 1861
Georgia	Jan. 19, 1861	Louisiana	Jan. 26, 1861

[11] The seizure of the United States property in January by State troops, acting under State authority is, of course, the striking instance of resumption of sovereignty. Governor Pickens of South Carolina, writing to the Provisional Congress regarding Fort Sumter, explained, "The State has held its right to the possession of Fort Sumter to be the direct and necessary consequence of its right as a sovereign State, to have the control of a military post within its limits". (Feb. 13, 1861).

vention of South Carolina had appointed to each of the slave-holding States a commissioner to invite cooperation in the formation of a Southern Confederacy. The Commissioner to Alabama, A. P. Calhoun, appeared before the secession convention of that State on January 8, 1861, to suggest tactfully that Montgomery was "spoken of" as a convenient meeting place for the proposed constitutional convention. The Alabama Ordinance of Secession on January 11, therefore, included a formal invitation to all the Southern States to meet with the people of Alabama to frame a provisional or permanent government for common peace and security.

The Constitutional Convention for the Confederate States met in Montgomery on the 4th day of February 1861. At the opening session, there were present representatives from the six seceded States, Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina.[12] The Convention was quite in the nature of an international conference. The rules of procedure were unanimously drawn on the principle that here was a congress of sovereign and independent States. The members were merely deputies, appointed by, and acting under specific instructions from, their respective State governments. Voting was by States, not individually by the members, each State having one vote and a majority of States being required to carry a motion. The most important work was done in secret session, and the members were threatened with expulsion for divulging any of the matters at hand.[13]

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[12] Concerning the qualifications of the Confederate "Fathers", Alexander Stephens (vol. 1, p. 325) writes:

"Of the personnel of this body of men, I may be excused for saying, in passing, that, taken collectively, I never was associated with an abler one. There was in it no one, who, in ability, was not above the average of the members of the House of Representatives of any of the sixteen Congresses I had been in at Washington: while there were several who may be justly ranked, for intellectual vigor, as well as acumen of thought and oratorical powers amongst the first men of the continent at the time.

They were not such men as revolutions or civil commotions usually bring to the surface. They were men of substance as well as of solid character, men of education, of reading, of refinement, and well versed in the principles of government. They came emphatically within the class styled by Carlyle 'earnest men.' Their object was not to tear down so much as it was to build up with the greater security and permanency."

[13] Howell Cobb to his wife, Feb. 6, 1861: "We have gone into secret session, and on pain of expulsion not permitted to divulge anything that is going on. The details would not however be interesting. I can say to you that whilst there are differences of opinion, there will in the end be great unanimity and our final action will prove satisfactory." Correspondence of Toombs, Stephens, Cobb. *Ann. Rept. Ameri. Hist. Assoc.*, 1911, vol. 2.

The delegates had been instructed by their State governments to form and put into immediate operation a provisional government modelled as nearly as practicable on the principles of the government of the United States. To this end, a Committee of Twelve was appointed, with Christofer Gustavus Memminger of South Carolina as Chairman. The work of this Committee was accomplished with phenomenal speed; its report was unanimously adopted on February 8th, and went into effect on February 9th with the election of Jefferson Davis and Alexander Stephens as President and Vice-President of the new Confederacy.[14]

Meanwhile, as this provisional government grappled with the problems of the impending conflict, a Committee on Permanent Government with two members from each State, under the chairmanship of R. B. Rhett of South Carolina, was writing the new constitution.[15] Its report was submitted to the Congress on February 26th, and with some few minor modifications, was adopted unanimously on March 11th, 1861. Copies of the Constitution were then sent on approval to the State Governments. Ratification was immediately forthcoming from the several States, with votes practically unanimous, for although there was considerable dissension even in 1861 as to the expediency of secession, there was apparently almost complete agreement among the legislators on the right of the States to leave the United States and to enter into the Southern Confederacy.

The gentlemen at Montgomery deliberately reenacted the rule of their Fathers at Philadelphia, producing an almost identical document, and making only such alterations, corrections, deletions, and additions, as appeared necessary to emphasize their concept of a "Federal Republic."[16] That concept, as we have pointed out, was one largely of an international organization: sovereign and independent States, voluntarily delegating enumerated powers

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[14] "We have changed the constituent parts but not the system of our Government. The Constitution formed by our Fathers is that of these Confederate States, in their exposition of it; and, in the judicial construction it has received, we have a light which reveals its true meaning." *Inaugural Address of Jefferson Davis.*

[15] South Carolina: Chestnut and Rhett.
Alabama: Walker and Smith.
Florida: Morton and Owens.
Georgia: Cobb, T., and Toombs.
Louisiana: DeClouett and Sparrow.
Mississippi: Clayton and Harris.
Texas was not represented, having entered the Congress late.

[16] Curry, p. 50. "The Constitution of the United States was copied with almost literal fidelity, differing from that of the fathers only in so far as it was explanatory of their well known intent."

for common purposes to a central authority, the delegation, however, involving no serious or permanent defection in the essential attributes of Statehood.

The Preamble was amplified: "*We, the People,*" of 1787 becomes in 1861. "*We, the people of the Confederate States, each State acting in its sovereign and independent character, in order to form a perfect Federal Government.*" The modifying phrase was added to forestall any argument for the future, such as had been made in the past, that the authors of the Constitution were the people *en masse* and not the States in their several sovereign characters.[17] T. R. R. Cobb, a member of the Committee that framed the Permanent Constitution, affirms in his *Notes*: "The Preamble holds unmistakable the sovereignty of the States and declared the Constitution to be a compact among them."[18]

In Article I, Section I, legislative powers were *delegated* and not *granted.* T. R. R. Cobb explains: "The Committee was determined not to admit any word which could be construed as favoring a national government."[19] This follows the old construction of Calhoun on the nature of sovereignty. Sovereignty, said Calhoun, is an entire thing. To divide it is to destroy it. In a democratic federal republic, sovereignty remains with the people; enumerated powers may be delegated but sovereignty remains invisible and unlimited.[20]

The taxing power, which had been a moot issue under the old Constitution, underwent considerable revision. Congress was given the power to lay and collect taxes for revenue necessary to pay the debts, provide for the common defense, and carry on the government. The "general welfare" phrase under the taxing power, which had permitted such an expansion of national activities under the Constitution of 1787, was deliberately omitted in the Constitution of 1861. Under the commerce power appropriations for internal improvements and protective tariff were specifically forbidden. Likewise the Confederate Congress was given power to establish post-*routes* rather than post-*roads.* The change in wording indicated that Congress was not to undertake any road-building or aids to transportation under the guise of the postal power. These practices they knew from experience had given the

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[17] Stephens, vol. 1, p. 335.

[18] A. L. Hull, *The Making of the Confederate Constitution, So. Hist. Assoc.*, 9: 272 (1905).

[19] *Ibid.*

[20] Calhoun, *Works*, vol. 1: *A Discourse on the Constitution and Government.*

national government a widening economic wedge into the political jurisdictions of the States.[21]

It was first thought that specific protection of slave property would induce other slave-holding States to join the Confederacy. Hence the Constitution made provision for the admission of other States by a vote of two-thirds of the House and the Senate, the Senate voting as an assembly of States. The Confederacy was also given the right to acquire new territory, such territory to be governed by the Confederate Congress until ready for admission as States to the Confederacy.

Provision was made for amendment of the Constitution on the demand of any three States, legally assembled in their several conventions. The Confederate Congress, on such demand, was to summon a Convention of all the States to discuss the proposed amendment. If the amendments were agreed upon by the Convention, voting by States, it was to be returned to the State legislatures or the State conventions. Ratification of the amendment by two-thirds of the States was required for any constitutional change.

Alexander Stephens comments:[22] "All of these amendments were decidedly of a conservative character . . . They were all . . . such as in the judgment of a majority of these States, the experience of seventy years had shown were proper and necessary for the harmonious working of the system."[23]

The salient features of the United States as an international organization were all retained in the Confederate Constitution. The problem of a fair representation of large and small States, of legal equality and factual disparity, was solved as in 1787 by a bicameral Congress. The Senate represented the States equally, the House represented proportionally the people of the several

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[21] Curry, p. 65: "The Constitution . . . asserted the derivative character of the Confederacy, the equality and sovereignty of the States, the limitations upon the powers of the general government, and devised such restrictions as to make almost impossible future aggressions and usurpations . . ."; p. 69: "The permanent Constitution was framed on the States Rights theory, to take from a majority in Congress unlimited control, and to give effective assurance of purity and economy in all national legislation . . ."

[22] Stephens, vol. 1, p. 339.

[23] Note: Some other changes, particularly in the relation of the executive to the legislature in the British manner, and in the financial system, have not been remarked here because they do not seem to bear directly on the international aspect of the subject. From the point of view of political science, it might be observed that the Confederate Constitution was superior in some respects to the Constitution of the United States.

States. Thus, each State had two Senators, and, on the basis of one representative for every fifty thousand inhabitants, South Carolina had six, Georgia ten, Alabama nine, Florida two, Mississippi seven, Louisiana six, and Texas six.

Distribution of powers was based on a cautious analysis of interstate interests. Powers delegated to the central government were those which could be exercised most conveniently for the good of all by a common agency. The enumeration of the powers to Congress corresponded to the list in the United States Constitution, with additional restrictions as above noted. The Bill of Rights which appears in the first ten amendments of the United States Constitution was introduced into the text of the Confederate Constitution as controlling the legislative powers. The so-called "elastic clause," however, was also included, giving Congress leeway to make all laws "necessary and proper" for carrying into execution the enumerated powers.

The "King-pin" clause of the United States Constitution was retained verbatim: "*This Constitution and the laws of the Confederate States made in pursuance thereof, and all the treaties made or which shall be made under the authority of the Confederate State shall be the supreme law of the land; and the Judges in every State shall be bound thereby, anything in the Constitution or laws of any State to the contrary notwithstanding.*" This was accompanied in the same article, however, by the guard of State Rights: "*The enumeration in the Constitution, of certain rights, shall not be construed to deny or to disparage others retained by the people of the several States.—The powers not delegated to the Confederate States by the Constitution, nor prohibited by it to the States are reserved to the States respectively, or to the people thereof.*"

Concerning the doctrines of nullification and secession there is no mention in the Confederate Constitution, although proposals were made for both in the Committee and in the Convention. It was evidently considered the better part of discretion to continue on the assumption that the latter at least was inherent in the States' Rights and therefore required no particular sanction in the Constitution.

The executive power was vested principally in the President, who was elected by that cumbersome creature of the States, the electoral college. Except for a change in tenure and some slight additional power over finances and patronage, the Confederate President had the same legal status as the President of the United States.

The judiciary was given compulsory jurisdiction over all interstate disputes and in controversies involving constitutional and international law. The judicial power was to be exercised by one Supreme Court and such inferior courts as Congress might establish. The Confederate judiciary was competent *"in all cases . . . affecting ambassadors, other public ministers, and consuls;"* in *"all cases of admiralty and maritime jurisdiction: all controversies between two or more States; between a State and citizens of another State, where the State is plaintiff; between citizens claiming lands under grants of different States,*[24] *and between a State or citizens thereof, and foreign States, citizens, or subjects."*

Interstate comity was secured, as in the United States Constitution, through the "full faith and credit" and "privileges and immunities" clauses. Provision was also made for interstate compacts on matters of sectional interest, particularly river navigation, within the ambit of the general organization.

Disarmament of the several States, except for police purposes, was obtained by a guarantee of collective security. *"The Confederate States shall guarantee to every State that now is, or hereafter may become, a member of this Confederacy, a republican form of government; and shall protect each of them against invasion; and on application of the Legislature (or of the Executive when the Legislature is not in session) against domestic violence."* And this guarantee was backed up with the standing army and navy of the central government.

The Confederate Constitution was designed to meet the needs of a group of states having common peace time interests and pursuits. War was not unexpected and yet was not anticipated by the Montgomery Convention. Admittedly the operation of the government under the constitution of 1861 was scarcely a fair test of its practicality as a project in international organization. That the Confederacy endured for only a short time and mainly during wartime does not deter us, however, from recalling it as an exemplification of the problems involved in the establishment and maintenance of international government.

The Confederate Constitution was founded on those fictions of international law which are still cherished by the governments of the world—the sovereignty and equality of States. It is instructive to note how these basic fictions were worked into the institutions and practices of an interstate organization which had at

[24] Note that cases involving diversity of citizenship generally are omitted.

least a *de facto* existence of four years. That the Confederacy did not survive was due primarily, of course, to defeat on the battlefield. Its collapse, however, must also be attributed to certain inadequacies and deficiencies of organization which are apparently inherent in the Confederate type of international government.

The principles of sovereignty and equality were rigidly adhered to in the formation and operation of the Confederacy, although the exigencies of war demanded centralization of authority. The Confederate Government could not secure from the States, even in the direst emergency, the men, money and munitions necessary for the common defense. The Confederacy was doomed to defeat when the Commander-in-Chief was flagrantly defied by the governors of the States. Governor Joe Brown of Georgia probably did more harm to the Confederacy than General Sherman of the U. S. Army. A proponent of nullification, he virtually invalidated conscription in Georgia, and attempted to recall the Georgia militia from the Confederate Army on the very eve of a critical battle with the Union army. So strong was the feeling for States' Rights that it was practically impossible to organize the Confederate judiciary, and the Supreme Court was never established because the States would not tolerate "a common arbiter." Summed up, the Confederate States of America put too great emphasis on States' Rights in theory, left too much independence to the States in practice and allowed too little coercive power to act directly from the central government upon the people as a whole. Thus the essay of the Confederate States of America in international organization, while negative in itself, has produced certain postulates of current significance.

The Confederate States failed to meet the very problems which now confront the United Nations. The lesson from the past is implicit. In this history of confederation, the centrifugal forces have too often proved stronger than the centripetal, and disobedience by the members has been more common than usurpation by the central government. Compulsory membership and coercive power are essential attributes of international government. A compact among nations supported only by moral suasion is really without sanction, for national honor is too often confounded with national interest. Moreover, if the international organization is to function at all, it must have all the powers necessary and proper to maintain an equitable peace as well as to prevent aggression.

The United States is pledged to participate in the new world order. In October, 1943, we joined in the Moscow Four Nation

Declaration, which promised "to establish at the earliest practicable date a general international organization." Accordingly, in September, 1944, the Dumbarton Oaks Conference attended by representatives from the United Kingdom, the Republic of China, the U. S. S. R., and the U. S. A. produced a formal plan for post-war international organization. This new covenant has as its principal organs a general assembly, a security council, an international court of justice, and a secretariat. In the Assembly all the States are equal and each State has one vote. On the Council, the "Big Four," "and in due course, France," will have permanent seats. Six non-permanent seats will be filled in biennial elections by the Assembly; the question of voting on the security Council is still under debate with unanimity the moot issue.

But structural planning and procedural details are unimportant. The recognition of sovereignty which implies the negation of coercion and the denial of power, the acceptance of equality with its corollary of unanimity—these are the pernicious prevarications which haves wrecked every previous confederation. So long as the United Nations gives even lip service to "the principle of the sovereign equality of the peace-loving states," the past foreshadows the future. The American Federal Union became the strongest "international" organization known to history when the fiction of States' Rights was destroyed by the auto-failure of the Confederacy. If the world is to profit by the experience of the American people, it will adopt no temporizing expedients, but will resolve upon a more perfect federation to promote general welfare and secure the common peace.

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RECORD OF A TEGESTA BURIAL MOUND IN PALM BEACH, FLORIDA

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Indian mounds and their contents are not uncommon in Florida, and a number of them have been excavated under scientific supervision or without benefit of science in various parts of the State. Records exist in scientific and non-scientific publications and I have no intention of reviewing these interesting and highly technical reports, which, frankly, are outside of my scientific field.

It is desired, however, to present certain facts concerning the recent excavation of a mound in Palm Beach, and record certain observations made by myself and Dr. Julian D. Corrington, also of the University Zoology Staff.

The Kahn Estate at 690 North County Road, Palm Beach, Florida, had been acquired as an admirable site for the Graham-Eckes School, and during recent expansion of this school's services, it became necessary to remove a large mound immediately to the west of the school building. This mound was perhaps 18 feet in maximum height, was approximately 100 feet in width, north to south, and perhaps of greater length east to west. It was overgrown with well-developed cabbage palms, seagrapes, and other trees typical of the area. The eastern extremity of the mound was perhaps 150 feet or more from the ocean beach, and the western extremity was approximately 100 feet from North County Road. A mound immediately to the south of the school property, according to local opinion, was probably an Indian living mound, while the school mound was presumed to be a burial or reburial mound. These opinions were made known to school authorities subsequent to the excavation of the mound on school property.

For some months negotiations had been under way to provide for the removal of the school mound, either for its potential shell content, or for its sand content, and preceding the present school year it was found necessary to arrange for the cooperation of the City in the removal of this sand to property west of North County Road, to develop a more suitable athletic field in that location, as well as to permit expansion east of North County Road. Photographs of the mound in its original condition are in the possession of the school.

Excavation was begun at the southwest side of the mound on

September 20th, and after it had proceeded through almost half of the mound, skeletal remains were encountered.

Such of these materials as could be removed were recovered by workmen and staff members of the school, under the direction of the Head Mistress, Miss Inez Graham. As the mound's crest was passed and excavation continued in a northeasterly direction, these remains became more numerous. Arrangements for the work were such that it was impossible to delay, and, because of previous contacts, Miss Graham telephoned the University of Miami, and asked for suggestions concerning emergency procedure which should be followed to safeguard any scientific information which might be brought to light.

During this conversation with me, at about three o'clock in the afternoon, I suggested that photographs be taken showing any skeletal materials in position in the sand, that observations be made as to the depth and arrangement of burial, and that the Smithsonian Institute be called by telephone for further advice. I encouraged Miss Graham to save all materials possible, for future study. At her invitation, I asked Dr. Corrington to accompany me and made arrangements for transportation which brought us to the site at dusk.

Conditions did not permit us to spend more than an hour, under flood lights, examining the undisturbed portion of the mound, which then was represented by perhaps one-tenth of its original size. We removed four skulls but found it impossible to trace complete skeletons, as we worked into the mound from the excavated side. Two skulls were upright in position and two were horizontal. The upright skulls faced north, the horizonal skulls faced west. As efforts were made to trace a skull beyond the axis and atlas, if present, a humerus might be encountered and then a new skull, or a femur. In other words, there appeared little organization of skeletal parts or isolation of burial, but a massing of bones which indicated that the mound might have been used for reburial of skeletons which were already considerably disarticulated.

The lower jaw was rarely preserved intact, smaller bones of the arms and legs were not as numerous as those of the upper arms and legs, vertebrae were poorly preserved, and scapulae and innominate bones all were fragmented. A few intact ribs were located, as well as some tarsals and metatarsals, carpals and metacarpals. Teeth appeared to be well preserved, and one complete lower jaw revealed almost perfect, though wellworn, dentition. Except for the skulls, most of the bones fragmented easily and

many were grown through by tree roots, some long bones resembling the units of a necklace strung on a root. All skulls were filled with sand.

Dr. Corrington and I observed no fragments closer than three to four feet from the surface, but members of the school staff indicated that material had been uncovered earlier which was within 18 inches of the mound surface. The staff could offer no evidence that any weapons, clothing, pottery or other materials had been found in the sand, confirming our limited observations at the time.

The strongly brachycephalic skulls, at first glance, appeared to be those of small people or children, but observations of the length of the long bones indicated an average stature of well over five feet, and a rumor that the skeletons were those of pigmies was patently unfounded.

Reference to Smithsonian publications would support the supposition that this material was Columbian or Pre-Columbian, of the group known as the Calusas (more properly called Tegestas on the southeast coast of Florida), and that the material uncovered was entirely in line with previous discoveries and not of any unusual character.

Inasmuch as over 70 skulls were recovered from the mound, and not carried away by workmen, the fragments visible indicated a burial of perhaps more than one hundred and fifty individuals.

On the 23rd Dr. T. H. Hubbell and Dr. H. B. Sherman, of the Biology Department of the University of Florida, visited the site. On the 24th, at the request of the Head Mistress, Dr. Corrington and I returned to Palm Beach and transported the material to the University of Miami for safe-keeping, for study by Smithsonian or other anthropologists, and for such ultimate disposition as might be determined by the Board of the Graham-Eckes School.

FOLKLORE AND PLANT LORE

S. C. Hood

Bradenton, Florida

The herb and root gatherers of ancient Greece performed certain mystic rites with sacrifices and supplication to the Gods, in order that the plants they collected might have proper strength for the treatment of disease. Today every physician begins every prescription he writes with a prayer to Jupiter. The orange tree, because it bears both fruit and flowers at the same time, was the emblem of fertility among all the eastern peoples. The Saracen brides carried wreaths of orange flowers to insure that their marriage would be fruitful and prosperous. Today brides carry bouquets of orange blossoms, although the significance of the custom has long been lost in the dust of antiquity.

Among the native Indian tribes of the West Indies the pineapple was the emblem of hospitality, and with this fruit they welcomed Columbus to their shores. The Spanish carried the fruit back to Spain, and adopted its significance. Its cultivation and attributes soon spread all over southern Europe, and on festive occasions the pineapple was the centerpiece of the table decorations, thus indicating the hospitality of the household. In northern Europe, where the fresh fruit was not readily obtainable, they carved out wooden pineapples and placed them over the doorways or set them on gateposts. In the form of this decoration, brought from Europe to America by the early colonists, the symbolism of the pineapple returned to its native land, and a conventionalized pineapple was placed on gate posts and over doorways, and carved on bedposts and other articles of furniture. Today the decoration is still in use by people who have no knowledge of its origin or of the significance of the design.

Thus old plant legends and ancient plant lore have been brought down through the ages into our everyday life, and permeate our language, our literature, our arts, and our religious rites. We still speak of "laureled brows," of "palms" of victory, of the "fig tree" of shelter, and the "corn" of abundance. We still "rue" the day, and the wise man is still a "sage." We still tell our secrets "under the rose," and extend the "olive branch" of peace.

As certain plants came to have special significance in the customs and legends of a people, then-ambitious families often began to identify themselves with one or another such plant; they used it as their symbol, and engraved it on their coat of arms.

Thus the Fabians, a prominent family of early Rome, were the Bean family; the Lentucini were the Lettuce family; the Coepiones were the Onion family; and Cicero was simply Mr. Chick Pea. Many ancient families claimed ancestry from trees. Virgil speaks of "Nymphs and fauns and savage men who took their birth from trunks of trees and stubborn oak." Today we have such family names as Oakes, Ashe, Beech, Birch, Nutt, Chesnut, and Pine. Sometimes the family tree was a fruit tree, and we encounter such family names as Apple, Peach, Plumb, Pear, Cherry, Olive, Coffee, and Orange. For flower names we have Rose, Lily, Aster, Heath, and Cotton.

Every religion has developed its own plant legends and used certain plants in its mystic rites. With the advent of Christianity this crop of legends was very greatly increased. Many legends long in circulation and identified with pagan rites were polished up a bit and served on a new dish; and many new ones were invented. There are over 40 plants named for the Virgin Mary and having appropriate myths assigned to them. The saint names among our plants are almost as numerous as they are on a Spanish map. Legends give about 30 plants a part in the Christmas story, and plants associated with Easter are even more numerous.

Ancient peoples lived in continual fear of witches, supposedly waiting to pounce on them and to afflict them with all sorts of ills of both body and mind, as well as to damage their property. Witches caused illness; they blighted crops, and brought disease to flocks and herds. They worked their wicked will through the use of certain magic plants, such as vervain, dill, saffron, monkshood, cudweed, plantain, and dyer's alkanet.

Since diseases were caused by witches, of course they were the only ones who could cure them; and witches (and priests) were naturally the first physicians. Some 200 plants were used by them to cure disease, and many of these have come down into present day medical practice, though the use of some rests only on their antiquity and reputation and not on any therapeutic value. Some of these witch plants were also used for sinister purposes, and poisoning was very common in those days. Among the plant poisons thus used were nightshade, henbane, monkshood, hemlock, and poppy.

One important part of the witch business was the dealing in love philters. For the brewing of the charms and concoctions they made use of the herb of basil, verbena, cyclamen, purslane, bedstraw, and periwinkle; or the root of male fern or mandrake; or the seed of cumin and endive. Most of these plants are still

believed by many to have some effect as aphrodisiacs. Since eligible males were at the mercy of witches with their powerful love potions, there had to be antidotes. And so from before the days of Pliny the root of the water lily and the amaranth were used to combat these charms; the leaves of the chaste tree or tree verbena, and the bark of certain willows were also used. Gerarde, in his Herbal of 1597, says: "The carrot serves in love matters, but the root of the wild species is more effectual than that of the garden form." Thus was life rendered complicated even in those good old days.

Since so many plants were used by witches to produce evil results, it was only natural that there should be many others useful for overcoming witch influence, and a long list of such plants could be given. Leaves of the rowan tree were placed over doorways, and hung in stables to protect the cattle. This rowan, or mountain ash, was the most powerful of all the anti-witch plants, and it would be interesting to know whether its ancient reputation had any bearing on the widespread planting of this tree along the highways in the French part of Quebec. Flax flowers were hung on the horns of cows to make the butter churn. Shamrock, white heather, verbena, hobble-bush, mugwort, and St. Johnswort were worn to protect the wearer from evil spells. Scott says, in one of his novels:

"Trefoil, St. Johnswort, Vervain, Dill,
Hinder witches in their will."

We look with amazement on these old legends and beliefs, and wonder that people could ever have been taken in by such childish tales; but it is even stranger that many of these plants are used in Europe and America for the same purposes today. There are a number of concerns in the United States still doing a considerable business in the sale of witch plants—not only to obeah men and cunjer women among the southern Negroes, but also to hex doctors, pow-wow men, and purveyors of charms and love potions all over the country. If all the pockets could be turned out, we might be much surprised at the collection of luck charms and witch plants found.

There is a mass of legends concerning what might be called malevolent plants—mostly old travellers' tales which grew with the telling. Thus there was the vegetable lamb, which grew on a plant stalk and had wool like a sheep. Many attempts have been made to identify this plant, but it was probably nothing more than a good, husky cotton plant. There was the barnacle tree, the fruit of which became a duck if it fell into the water, but ran away as a rabbit if it fell on the land. Then there was the terrible Upas tree,

which was so deadly that animals coming near it were killed by its effluvia, and birds flying over it dropped dead to the ground. There is a Upas tree, a native of Java, and it is very poisonous. A tiny droplet of the sap falling on the skin causes a bad ulcer to form, and even the dew dripping from the tree may cause serious poisoning. The sap of this tree is sometimes used for an arrow poison. Our manchineel tree of south Florida is almost as bad.

Another of these supposedly malevolent plants was the rattlesnake tree of Mexico, the branches of which were writhing serpents waiting to seize and devour any person coming within reach. There is a rattlesnake tree; but the long, drooping branches, instead of being serpents, are armed with long, hooked thorns, and it is possible that small animals may sometimes become entangled in them and be unable to escape. Another old tale is that of the man-eating plant of Madagascar, which has been served up periodically for the past 300 years, and even today occasionally makes the Sunday supplements. This plant is supposed to consist of long, leafless branches that wave about, seeking a victim. To the natives this plant is said to be a god to whom they offer sacrifices, and human victims are thrown into its terrible embrace and devoured. This tale was probably built around one of the larger insectivorous plants, which do occasionally entrap and devour tiny animals and birds in a manner similar to that in which our common pitcher plants, sundew, and Venus fly-trap catch insects.

One of the most potent magic plants of antiquity was the mandrake, first cousin to the belladonna of the pharmacy. Because the root of this plant often took a shape like the human form, it was credited with marvelous powers and was in great demand. When found the plant must be quickly circumscribed by a piece of iron, and some soil carefully removed from around it. A dog is then tied to the root, and one must then run away for some distance, and with the ears covered, call the dog. As the angry plant is pulled out by the dog, it utters a shriek which brings death or madness to all hearing it. Shakespeare says, "and shrieks like mandrakes torn out of the earth, that living mortals, hearing it, run mad." Later it was found that the plant can be pried out with the tip of a sword, if first the sign of the cross is made over it, and the face is kept turned away from it and toward the west. Once the root is secured it must be kept wrapped in a white cloth and bathed with holy water every Friday. So powerful was the mandrake as a witch plant that the very possession of it brought one under suspicion. In 1630 three women were executed in Hamburg for having mandrakes in their possession. Twenty books

have been written on this plant, setting forth its use in casting spells, in making charms and love philters, and in medicine.

Do you wish to become wealthy? I will tell you how you can do it. First you must get some fern seed. Of course, this is not easy, but the method is interesting. According to old legends, the fern seeds only on Midsummer Eve, and is under the special protection of the Devil. For several days beforehand you must eat certain magic plants, and must not during that time go to church or say prayers. Then, barefooted and clad only in a shirt, go at midnight on Midsummer Eve to look for a seeding fern. Goblins will try to lead you astray, and will perform all sorts of antics to make you laugh or speak; but if you so much as utter a sound, the Devil will tear you in pieces. Finally, when you have found the seeding fern, you must catch the seed in a chalice-cloth, or else the Devil will take it from you. If you prefer, you can have the Devil bring you the fern seed on Christmas night. If this is the method you choose, for four weeks before Chirstmas you must not go to church, say prayers, pay the preacher, or use holy water; and all this time you should keep your mind on devilish thoughts. Then, between 11 and 12 o'clock on Christmas night, take your stand at a crossroad over which a corpse has been carried to the churchyard. You will see many people long since dead, and goblins will dance and try to make you speak, and will tear you to shreds if they succeed. If you undergo this ordeal in silence, there will finally come an old man dressed as a hunter. This is the Devil, and he will, after a time, hand you a package of fern seed. Whichever way you choose, the ordeal may be a little trying to weak nerves; but it is worth while to go through with it, for a tiny bit of this fern seed, carried on the person, will enable you to do the work of 30 men. If placed in the shoes it will render you invisible. It will reveal to you all buried treasure, and where gold may be found. Furthermore, with this fern seed in your possession, you can make the Devil bring you all sorts of treasure with no trouble to yourself.

Try it sometime!

SOME ASPECTS OF THE HISTORY OF CITRUS IN FLORIDA

T. Ralph Robinson

Terra Ceia, Florida

Interest in the early history of citrus fruits has been awakened in recent years by new facts brought to light bearing on their original introduction into the New World. Perhaps chief among these discoveries is that Columbus himself, on his second voyage, was the bearer of seeds that gave rise to the first citrus orchard in America. Credit for this important find is owing to Virginia Kift Barns, who published an account of her discovery in a Florida journal, "The Citrus Industry," October, 1934. Up to that time no record existed in American literature of the exact date or manner of introduction of citrus into this part of the world.

In the course of a survey on raw products carried out by the New York City Department of Markets, Miss Barns consulted Bartolomé de las Casas' "Historia de las Indias." This history, written over a period of years (1527-1559), remained unpublished until 1875, when it was finally printed in Spanish. Only parts of this work have yet been translated into English. The portion with which we are concerned is worth considering in some detail. Referring to Columbus' second voyage, Las Casas tells of his departure from the Bay of Cadiz on September 25, 1493, and his stop at the island of Gomera, one of the Canary group (Oct. 11-13), awaiting favorable winds. There he bought seeds and livestock, including eight pigs. Las Casas writes: "From these eight pigs there have multiplied all the pigs which unto this day inhabit the infinite Islands of all these Indies. They bought hens and also grains and *seeds of oranges, lemons, citrons,* melons, and all kinds of garden vegetables, and this was the origin of everything that there is today of the things of Castille." Thus the exact date of introduction and the exact spot in the Old World—Gomera in the Hesperides, or Canary Islands—from which our first citrus came were both recorded by the Spanish friar.

Las Casas goes on to relate that on November 22, 1943, Columbus sighted the island of Hispaniola (that is, Haiti, also called San Domingo), and "here he unloaded his ships of provisions, livestock and materials, built a fort, storehouse and church, set out orchards, planted gardens, and with great diligence erected a new city." This city was named "Isabella," and was located on the

north side of the island, not far from the present town of Monte Cristo in San Domingo.

That the citrus seeds sown by Columbus sprouted and prospered we have no reason to doubt. We have, in fact, Herrera's statement regarding Hispaniola and how well it had proved suited to the Negroes imported from Africa: "*Like* oranges, they found their proper soil in Hispaniola and it seemed even more natural to them than their native land." Also we are told by the naturalist Oviedo, who was in Hispaniola from 1514 to 1525, that "orange trees from Castile were brought to this Island of Hispaniola and they have multiplied so abundantly that they are now past counting; the fruit is very good, both sweet and sour." Thus the spread of citrus must have been very rapid in the two or three decades following the introduction by Columbus. Doubtless Hispaniola thus served as a distributing center for the neighboring islands of the West Indies, for the mainland of the Americas, and possibly for Florida, though there were of course later introductions direct from Spain.

Just when and by whom citrus was first introduced into Florida remains to be discovered. Perhaps a plain statement may repose in some neglected manuscript or publication, as did the long buried record of Columbus' part in bringing citrus seeds to the New World. One of my objects in reviewing this subject is to stimulate historians and others to be on the watch for horticultural information of this kind when engaged on studies of a different order.

It is true that in 1577 Bartolomé Martinez, in a letter to the Spanish king, states that he planted with his own hand orange and fig trees at Santa Elena, located on the North Carolina coast. Also, in April, 1579, Pedro Menendez Marques, reporting progress at St. Augustine, states, "there are beginning to be many of the fruits of Spain, such as figs, pomegranates, oranges, grapes in great quantity." This would indicate that citrus had been introduced earlier, possibly by as much as several decades. However, Hume[1] is of the opinion that the introduction of citrus fruits into Florida did not antedate 1565, the year in which St. Augustine was founded. Certain it is that St. Augustine and its environs gradually became one vast orange grove, with schooners carrying loads of the golden fruit to the northern coastal cities over 200 years ago.

It is doubtless true, as Hume states, that the introduction into the St. Augustine area was by seed rather than by grafted or layered plants. In the case of citrus that fact would not be as great a

[1] Hume, H. H., *The Cultivation of Citrus Fruits*. (New York: Macmillan). 1926.

handicap as it might be with nearly all of the other important tree fruits of the world, seedlings of which commonly give rise to plants of inferior and widely divergent fruiting types. In fact, the citrus group and one race of mango are the only important tree fruits known that in the vast majority of instances "come true from seed." This is because their seeds develop extra embryos derived from the mother tissue of the seed, the nucellus, these extra embryos being therefore genetically the same as buds taken from the mother plant. Even more remarkable is the fact that sprouts from these extra embryos frequently, and in some varieties entirely suppress or supplant those springing from the true or seminal embryo, so that the resulting population resembles the seed parents in all essential characters. This important fact was not recognized until 1878, when Strasburger announced the polyembryonic nature of citrus seed. It doubtless accounts for the fact that there is a remarkable uniformity, generally speaking, in the fruits produced by the old seedling groves that still furnish an important part of the Florida orange crop. These seedlings doubtless trace their ancestry back to a very few parent orange trees that survived the disastrous freeze of 1835, which all but wiped out the sweet orange groves of Florida.

The Dummitt orange grove on Merritt's Island, opposite Titusville, was one of the few surviving groves after that truly great freeze. This grove was unique in that it was not a seedling grove but was composed of trees top-worked or grafted on sour orange rootstocks at a height of three feet from the ground. The grafting took place about 1830. That they were grafted trees was discovered when I visited the grove in 1926. The graft union is plainly shown in photographs taken at that time, and reproduced in an article on the history of the grove published in the Proceedings of the Florida State Horticultural Society for 1926. These photographs have also been republished in the recent monumental work on the citrus industry edited by Webber and Batchelor.[2] Webber points out that this was probably the first instance of the working over of a wild sour orange grove; the using of such volunteer trees as grafting stocks did not become a general practice until about 1865 or 1870. Despite the fact that this old grove has reverted to a jungle condition several times in the past century, there were still some trees alive according to last report. These veteran survivors of a past era should be promptly acquired and cared for by some official State organization, possibly the Florida Forest and Park Service. It is

[2] Webber, H. J., and L. D. Batchelor, *The Citrus Industry*. Vol. 1. (Berkeley and Los Angeles: University of California Press). 1943.

safe to say that if California could boast of such historic trees they would constitute a shrine to be visited annually by throngs of citrus growers and other visitors.

Notwithstanding the mass uniformity of citrus seedlings, enough variation has arisen, due to mutation or possibly to hybridization, to give rise to most of the valuable orange varieties grown in Florida today. In fact, the Valencia orange is the only budded variety of sweet orange widely grown in this state that is a direct importation from the Old World. Such varieties as the Parson Brown, Pineapple, Hamlin, Homosassa, Enterprise, and Connor, which constitute the great bulk of Florida shipments (exclusive of Valencia and seedling oranges), owe their origin to selected seedlings propagated by budding. The practice of budding was in many instances resorted to in order to utilize as rootstocks the so-called "wild" sour oranges that had sprung up as volunteers, forming thickets along such streams as the St. Johns and Oklawaha rivers. Indian camping and hunting parties are generally credited with the spread of these "natural groves," the fruit and seeds dropped by them around their camp sites giving rise to large colonies of descendants in the course of time. On such grove in the Okaloacoochee Slough of the Everglades is estimated to have produced the equivalent of 10,000 boxes of sour oranges annually—until overdrainage and subsequent fires practically destroyed it. It is no wonder that some early visitors to Florida thought that oranges were native to the state, when they saw such "wild" trees competing with bays and cypresses for the possession of low rich ground.

Going back to the seeds brought to the New World by Columbus, it will be recalled that no mention is made of grapefruit, Florida's unique contribution to the citrus markets of the world. Not only was grapefruit as we know it unknown to the Old World in Columbus' time—it was and is practically to this day unknown in the Orient, whence all our other citrus fruits originally came. The nearest counterpart to grapefruit in the Orient is the pummelo or shaddock, a native of the islands of the Malayan Archipelago and Polynesia. The name "shaddock" was used in the West Indies for the large, thick-skinned pummelos, because a certain Captain Shaddock was credited with having brought the seed from the East. The fruit was first planted in Barbados late in the 17th century. The shaddock was grown chiefly as a curiosity, although some of the oriental varieties are highly esteemed in their native lands. It now appears likely that it was from the shaddock that the New World acquired the wonderful fruit that we call grapefruit, by mutation or perhaps through chance hybridization.

Grapefruit is first mentioned, under the name "forbidden fruit," as occurring in Barbados by Griffith Hughes in 1750, and is recorded from Jamaica as "forbidden fruit or smaller shaddock" by Patrick Browne in 1789. In 1814 John Lunan used the name "grapefruit" in his Hortus Jamaicensis. Despite efforts to change the name to "pomelo" the name grapefruit has come into wide use and seems certain to persist. Although for a long time grouped with the pummelos, grapefruit is now recognized as a distinct botanical species, *Citrus paradisi* Macf. One fundamental difference between grapefruit and the shaddocks is the fact that the latter are unique among citrus fruits in having seeds with but a single embryo, while grapefruit seeds are polyembryonic. This would seem to indicate that grapefruit arose through hybridization between a shaddock and an orange, the polyembryonic character of the orange being dominant. We of the U. S. Department of Agriculture have attempted by crossing to re-create grapefruit, but thus far without success. This is not surprising, since the chances of striking exactly the same combination of characters in a limited number of hybrid seedlings is after all rather remote.

The merits of the new fruit were apparently appreciated by a select few, but it failed to meet popular approval for a surprisingly long time. Introduced into Florida about 1809 by Don Philippe, a Spanish nobleman located near Safety Harbor on Old Tampa Bay, it spread slowly but was grown chiefly as a curiosity or for home use. Not until winter visitors from the North developed a liking for grapefruit was any trade in it established. This happened sometime between 1880 and 1885, the first shipments north being made in barrels that netted about fifty cents per barrel. Only with the coming of the present century did grapefruit really begin to command a place in the fruit markets of the nation. Once started, the demand increased at a pace hardly paralleled by that shown by any other newly introduced fruit.

An important contribution to the world-wide popularity of grapefruit was the discovery in Florida of a seedless variety generally known as the Marsh Seedless, named for the man who initiated its propagation and distributed it from his Lakeland nursery. Conflicting reports as to the origin of this variety led me to make a thorough investigation of the matter in the spring of 1933. Fortunately this was done while there were still living a number of persons entirely familiar with the original tree and its history. My findings were reported in the Journal of Heredity in November, 1933. The parent tree, a seedling, grew in the grove of William Hancock at Socrum, about 12 miles north of Lakeland. It was a

bearing tree when Hancock bought the place in 1862, and was in a decadent condition when the freeze of 1894-95 killed it. Propogation had, however, been started by several persons about 1885, although the value of the variety was not fully appreciated for another 30 years. The Marsh Seedless has been the predominant variety in practically all recent plantings, and is almost the only one grown in the Southwest and in foreign countries that have taken up the growing of grapefruit recently.

A further impetus to grapefruit consumption was furnished when it was discovered, at the time of World War I, that grapefruit would lend itself to canning, making it available for use the year around. How important that factor has become may be realized when it is stated that in recent seasons processed grapefruit has accounted for 50% or more of the total production in Florida. Of course, the demand growing out of the requirements of the Armed Forces and Lend-Lease has had an important bearing on this phase of grapefruit utilization, but even before the war as much as one-third of the crop went into cans.

Another contribution that Florida is at the present time making to the citrus situation is the outgrowth of a citrus breeding program initiated by the U. S. Department of Agriculture in 1893, over half a century ago. At that time Swingle and Webber, in the attempt to create hardier sweet oranges, made numerous crosses between the hardy trifoliate orange and the common sweet orange. Many hybrids, called "citranges," were produced, but none that would serve as true orange substitutes. The program of research was gradually expanded until hybrids had been secured between practically all the main species and varieties of true citrus, and involving some of the more closely allied citrus relatives—an accomplishment unparalleled in the field of subtropical horticulture. The particular hybrid that is now making its debut is that between the grapefruit and the tangerine, known as the tangelo. Thousands of seedlings were grown and tested to secure a half dozen tangelo varieties suited to commercial handling, and maturing at different periods so that tangelos might be available practically throughout Florida's shipping season. It has been my privilege to be intimately associated with this breeding program for the past 25 years, and it is a great satisfaction to see the growing popularity of this new fruit. The tangelos as a class more nearly resemble an orange of superlative quality than they do either of the parent fruits. Their high color of flesh and of peel makes them attractive to the eye, and they bid fair to take an important place in the citrus market, particularly in the fancy fruit and private order trades. The

Temple orange, evidently a natural hybrid, should doubtless be classed with the tangelos, which it resembles in many respects. Thus far the tangelos have not appeared very well suited to other citrus growing regions of the United States, so that Florida may prove to have a practical monopoly of this fruit, as it has of the tangerine.

No discussion of citrus developments in Florida would be complete without some mention of the social effects of what may be termed the industrialization of citrus handling. Time was, within the memory of many of us, when a good part of the fruit leaving Florida was packed by the grove owners themselves, in crude packing sheds and with still more crude equipment. The labor for picking and packing was recruited from the immediate neighborhood, and the payroll thus locally distributed was a potent factor in building up fairly prosperous rural communities.

With the passing of the local car-a-day packing house, and the centralization of fruit handling through very large and well-equipped packing houses serving a wide territory, the picture has greatly changed. The labor of picking and packing has gradually passed into the hands of migrant workers, and the effect may be seen in the decline of some of our rural communities. Greater efficiency both in packing and in marketing is certainly attainable through the present centralization, but it is desirable that the social problems arising therefrom should be recognized and that counter measures be taken wherever possible. It is important that a large proportion of our rural youth should find their surroundings sufficiently attractive and their employment sufficiently remunerative to make them desire to follow the horticultural pursuits of their fathers, instead of drifting to the cities, or perhaps becoming migrant laborers themselves.

Reference has already been made to the recent book edited by Webber and Batchelor, entitled "*The Citrus Industry,*" and issued by the University of California Press. Anyone interested in the development of this industry, not only in Florida but elsewhere in the citrus-growing regions of the world, will find this authoritative work invaluable. Another fascinating work, from both a historical and a literary point of view, is "*Hesperides, a History of the Culture and Use of Citrus Fruits,*" by S. Tolkowsky, published in London in 1938. The author has made an exhaustive search of the ancient literature—Latin, Greek, Sanskrit, Hebrew, Arabic, Chinese, Persian, East Indian, and Malayan—as well as of works in the more recent European literature, in developing his theme. His greatest contribution to citrus history is his setting back by about

eight centuries the probable date of introduction of oranges and lemons into the regions bordering the Mediterranean—especially Italy. Most writers, following the conclusions of Gallesio, have maintained that these fruits did not make their appearance in Italy and neighboring countries until the 10th century A. D., although conceding that the citron was known and grown throughout the Mediterranean Basin for over a thousand years previous to that time—in fact, from the time of Theophrastus.[3] Tolkowsky shows, both by literature references and by the reproduction of murals and friezes dating back to the days of Pompeii, that lemons and oranges of a sort were known at that period of Roman history. His erudite researches thus do more than trace the history of citrus; they give an insight into the art, customs, commerce, and very lives of these ancient peoples.

[3] It is an interesting fact that Theophrastus, in describing the flowers of the citron, was the first writer (or botanist) to suggest in effect that flowers had both male and female parts. At least he stated that "of the flowers those that have, as it were, a distaff projecting in the middle are fertile, while those that have it not are infertile." His observation holds true to this day, many of the flowers of the citron being non-pistillate, and thus purely male in character.

NOTES ON THE FIRST PLEOPOD OF THE MALE CAMBARINAE (DECAPODA, ASTACIDAE)[1]

Horton H. Hobbs, Jr.

University of Florida

Andrews (1910) made an excellent anatomical study of the first pleopod of male crayfishes of the genera *Cambarus* (=Cambarinae) and *Astacus*, and proposed a nomenclature to be applied to the terminal elements. Later I adopted another terminology that I used in describing seven new crayfishes from Florida (Hobbs 1940: 388). The study of the pleopod was continued, and in 1942 I attempted to homologize its terminal elements throughout the Cambari (=Cambarinae). At the same time I proposed that a terminology based on the relative position of the terminal elements of the hypothetical generalized pleopod be utilized in all descriptions. Further, a standard anatomical position for describing the pleopod was suggested (Hobbs 1942a).

A subsequent study of the pleopods of the previously known species and subspecies, and those of several undescribed forms, has necessitated a more restricted use of the term *caudal process*. I have already pointed out that the homologies of the caudal process are confusing. "It is not uncommon to find the area from which the caudal process arises so accentuated as to practically lose its characteristics as a process. This condition may be found in the pleopods of *Cambarus advena, Cambarus rogersi* and *Cambarus alleni*.

"In certain species extra processes are added . . . and . . . it is sometimes difficult to decide which is the caudal process and which are the adventitious processes. All of the latter are outgrowths from the caudal region, and where there are several of these there is generally one arising from the central part of the knob while the others are processes from the rim." (Hobbs 1942a: 56-57.)

In proposing this terminology I suggested the use of "process" for any single terminal outgrowth regardless of its nature, and "projection" for any terminal outgrowth consisting of a fusion or partial fusion of two of the terminal processes. The only "projection" cited was the so-called "central projection," which consists of the juxtaposed centrocaudal and centrocephalic processes. Certain problems have since arisen which make it necessary to restrict, at least in part, both definitions.

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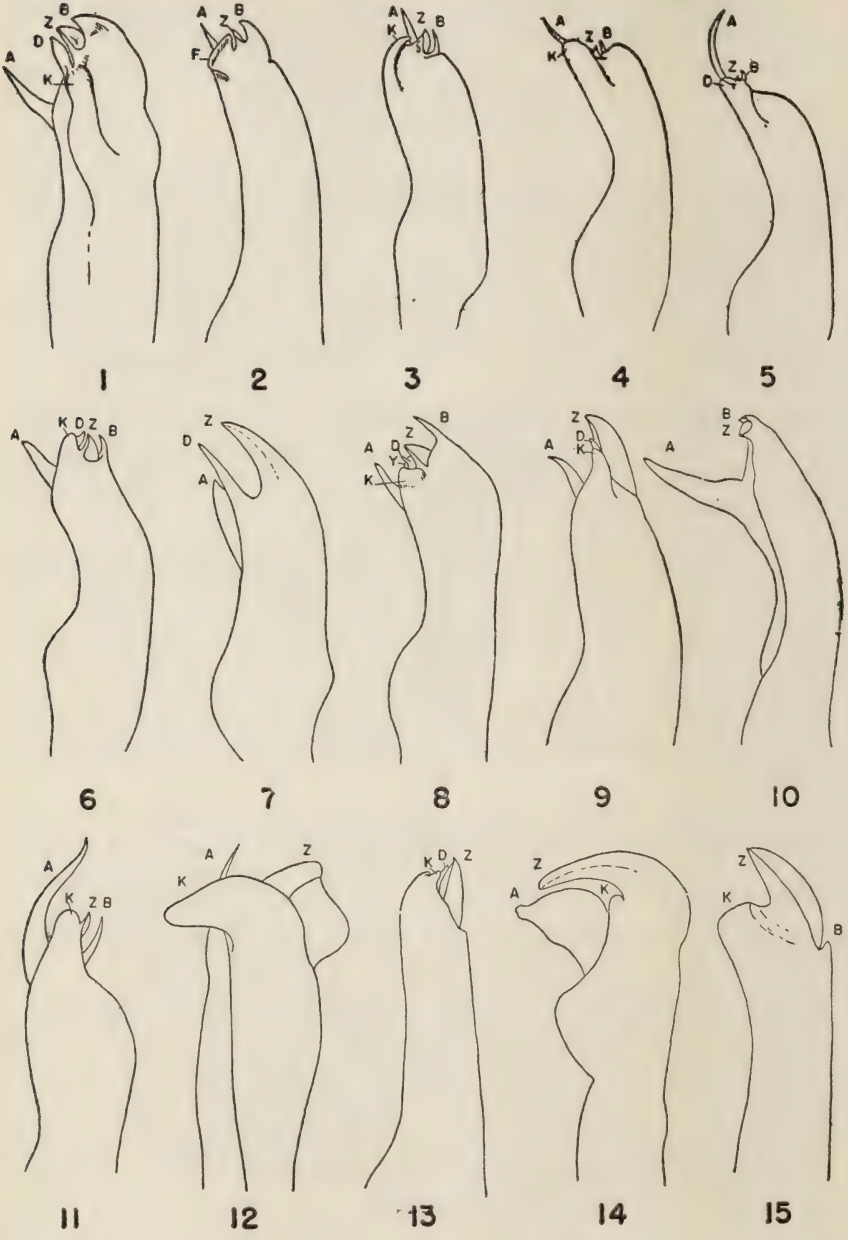
[1]Contribution from the Department of Biology, University of Florida.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In many instances it is impossible to determine whether the so-called caudal process consists of a single element or a complete fusion of the actual process with one or more adventitious processes (see below), and sometimes the actual process is so closely applied to an adventitious process that it is an arbitrary matter to decide whether or not the two are "partially fused." Therefore the term "projection" should be used only in designating the *central* projection.

Another difficulty has arisen in connection with the use of the term "caudal process." For example, the caudal element of *Procambarus pictus* (fig. 8) consists of a swollen basal portion from which projects a small subacute spine partially covered by a hood-like outgrowth from the mesial side of the swollen basal portion. By comparing the pleopod of *P. pictus* with those of related species it may be seen that the subacute spine is actually the caudal process, whereas the hood-like outgrowth is an enlarged adventitious process. If the pleopod of *P. pictus* is compared with that of *P. rogersi rogersi* (fig. 12) it may be seen that the actual caudal process and the adventitious process are absent in the latter, and that the large thumb-like protuberance directed across the caudodistal end of the appendage of *P. rogersi rogersi* corresponds to the swollen basal portion of the pleopod of *P. pictus*. For this and similar

Explanation of Plate

Crayfishes of the Subfamily Cambarinae

First Left Pleopods of First Form Males

A—mesial process
B—cephalic proces
D—caudal process
F—caudal element
K—caudal knob
Y—adventitious process
Z—central projection

Fig. 1.—*Procambarus hayi* (Faxon), Noxubee County, Miss.—lateral view
Fig. 2.—*Procambarus shermani* Hobbs, Santa Rosa County, Florida—lateral view
Fig. 3.—*Procambarus rathbunae* (Hobbs), Okaloosa County, Florida—lateral view
Fig. 4.—*Procambarus apalachicolae* Hobbs, Bay County, Fla.—lateral view
Fig. 5.—*Procambarus latipleurum* Hobbs, Gulf County, Fla.—lateral view
Fig. 6.—*Procambarus bivittatus* Hobbs, Santa Rosa County, Florida—lateral view
Fig. 7.—*Cambarellus schmitti* Hobbs, Gilchrist County, Fla.—lateral view
Fig. 8.—*Procambarus pictus* (Hobbs), Clay County, Florida—lateral view
Fig. 9.—*Procambarus spiculifer* (LeConte), Jackson County, Florida—lateral view
Fig. 10.—*Paracambarus paradoxus* (Ortmann), State of Puebla, Mexico—lateral view
Fig. 11.—*Procambarus alleni* (Faxon), Citrus County, Florida—lateral view
Fig. 12.—*Procambarus rogersi rogersi* (Hobbs), Calhoun County, Florida—caudal view
Fig. 13.—*Procambarus acherontis* (Lönnberg), Seminole County, Florida—lateral view
Fig. 14.—*Cambarus floridanus* Hobbs, Leon County, Florida—lateral view
Fig. 15.—*Procambarus advena* (LeConte), Clay County, Fla.—lateral view

reasons "caudal process" and/or "adventitious process" should also be restricted to apply only to acute, spiculiform, plate-like or blade-like extensions borne on the distal surfaces (caudal, caudolateral, or caudomesial) of the appendage. The swollen area (which is not always present, *viz.* in *Cambarellus schmitti,* fig. 7) from which one or more of these caudal or adventitious processes arises is designated the *caudal knob.*

Even with the restrictions in terminology suggested above, there are still certain difficulties. For example, the caudal element of the pleopod of *Procambarus shermani* terminates in a thin, curved, blade-like edge (see fig. 2). Looking at this appendage alone, one would be unable to determine whether this structure is an extremely atypical caudal process or a fusion of the caudal process with one or more adventitious processes; but upon comparing the pleopod of *shermani* with those of related species, *P. rathbunae, apalachicolae,* and *latipleurum* (figs. 3, 4, and 5), and also with that of *P. hayi* (fig. 1), the homologies of the caudal element become evident. Although there are several possible interpretations which would account for its formation, the following seems most probable. The caudal element of the pleopod of *P. shermani* apparently consists of a much reduced caudal knob, bearing a sharpened ridge which represents a lineal fusion of the caudal process with one or more adventitious processes. If this interpretation is accepted then it is incorrect to refer to these fused processes and knob as the caudal *process;* and I propose that these fused parts be termed the "*caudal element.*" The "caudal element" is defined as that portion of the pleopod which includes the caudal knob, the caudal process, and any adventitious processes that arise from the knob; *any one or more of these parts may be lacking.* Thus in comparing figures 2 and 8: K+D+Y (or any of these)=F.

A Correction.—Hobbs 1942a: Plate II, Fig. 10, Letter "A" should be replaced by letter "B."

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A BIOLOGICAL ANALYSIS OF THE FOOD AND FEEDING HABITS OF TWO FROGS, *HYLA CINEREA CINEREA* AND *RANA PIPIENS SPHENOCEPHALA*[1]

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The earliest extensive and detailed studies of the food and feeding habits of animals were made in an attempt to determine the economic status of particular species and groups. Thus the classical studies of Fisher (1894) on the foods of hawks and owls, and the investigations by Kirkland (1897, 1904) on the food of the common toad, were carried out in order to establish or measure the worth of these forms to agriculture. The vast store of data on the food of birds accumulated by the U. S. Biological Survey and its successor, the U. S. Fish and Wildlife Service, has resulted from studies which in the beginning were motivated almost solely by a desire to determine the rôle played by birds in relation to man's fight against weeds and insects. Viewing such investigations against the broader ecological background of today, however, it can now be seen that the food and feeding habits of an animal afford one of the best indices of its place in the economy of nature. Knowing what an animal eats not only enables us to estimate the toll levied by the species on other organisms, but also suggests the degree of its adaptability to changes in environment, and furnishes much information about its life history and habits.

The investigation upon which this paper is based had for its object determination of the food and feeding habits of two frogs common in northern Florida. These species—the green tree-frog, *Hyla cinerea cinerea* (Schneider), and the southern leopard-frog, ***Rana pipiens sphenocephala*** Cope—were chosen for this study for several reasons. The tree-frog is a representative of the large family *Hylidae*, the leopard-frog of the *Ranidae*. Each is probably the most abundant species of its family in the Gainesville region, and both are relatively easy to capture. Because of their numbers collection of large series was thought unlikely to deplete the local populations seriously ;[2] and because of their relatively small size ex-

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[1] Contribution from the Department of Biology, University of Florida, Gainesville, Florida.

[2] It is worthy of note that those stations where very large numbers of individuals were collected in 1935 appeared to be as densely populated in 1936 as they were before the collecting was begun.

tensive collections could be handled with comparative ease. The two species differ strongly in habits and habitat, and it was thought that these differences would be reflected in their food. Finally, published accounts of the habits and food of *Hyla cinerea* and *Rana p. sphenocephala* (or closely related forms) as observed outside of Florida seemed at variance with my own preliminary observations in the Gainesville area. The two species were studied in their natural habitats, month by month throughout a calendar year. As the study progressed, particular attention was given to seasonal changes in and the influence of the breeding season upon food habits, and to the factors that determine the hours of feeding.

Review of Previous Studies

The feeding habits and food of frogs and toads in the United States have been studied by a considerable number of workers. The contributions of Brakely (1885), Kirkland (1897), Garman (1901), Needham (1905), Dickerson (1906), Surface (1913), Drake 1914), and Dyche (1914) were reviewed and summarized by Munz (1920), who studied the food habits of eight New York species during transformation. Haber (1926) discussed all of the above-listed papers, and in addition the work of Abbott (1882), Kirkland (1904), Miller (1909), Wright (1914, 1920), Munz (1920), and Kellogg (1922). Wright (1932) recorded the food of frogs and toads inhabiting the Okefinokee Swamp, and referred to the work of some authors not mentioned above. One of these is Force (1925), who examined the stomachs of 46 specimens of the leopard-frog. Smith (1934) summarized the available information on the feeding habits of all the Kansas species.

The following students have also published short notes on the food or feeding habits of various species: Garnier (1883), on *Rana septentrionalis* Baird; Abbot (1884), on *Scaphiopus holbrookii* (Harlan); Garman (1891), on *Rana pipiens* Schreber, *R. catesbeiana* Shaw, *Bufo l. lentiginosus* Cope, *Hyla cinerea* Schneider, and *H. versicolor* LeConte; Davis (1907), on *Rana virgatipes* Cope; Deckert (1914), on *Bufo quercicus* Holbrook; Pope (1915) on *Rana septentrionalis;* Shufeldt (1917), on *Rana aesopus* Cope; Fisher (1920), on *Scaphiopus holbrookii;* Barbour (1920), on *Rana sphenocephala* Cope; Deckert (1921), on *Hyla squirella* (Latreille); Noble and Noble (1923), on *Hyla andersonii* Baird; Drayton and Johnson (1935), on *Rana catesbeiana;* Eckert (1934), on *Bufo californicus* (Camp); Frost (1935), on *Rana catesbeiana;* Trowbridge and Trowbridge (1937), on *Scaphiopus bombifrons* Cope (larval stages); James (1939), on *Rana sylvatica sylvatica* LeConte (effects of diet upon intestinal length); Baker (1942), on *Rana cates-*

beiana; Larson (1943), on *Bufo americanus americanus* Holbrook; Bragg (1943), on *B. a. americanus, B. cognatus* Say, *B. compactilis* Wiegman, *B. woodhousii woodhousii* Girard, and *B. woodhousii fowleri* Hinckley; and Sweetman (1944), on *Hyla versicolor.*

Although there is very little published information on the habits of either *Rana p. sphenocephala* or *Hyla c. cinerea,* a few observations on these or closely allied forms are available.

Force (1925) examined the enteric contents of 46 leopard-frogs from Oklahoma. She found that 10 of them had empty stomachs; the remaining 36 had eaten the following: beetles (Elateridae 38%, *Lachnosterna* 4.5%, Coccinellidae 4.5%, Scarabaeidae 1.8%, Cucujidae 1.8%, Dytiscidae 2.7%, and Lamiidae and Cicindelidae 0.9% each), larvae 11%, ants (Myrmicidae 16%, Formicidae 2.7%), Hemiptera (Saldidae 1.8%, Belostomatidae 1.8%, Membracidae 0.9%), and crayfish 0.9%.

Drake (1914) examined 209 specimens of the northern leopard-frog, *Rana p. pipiens,* from Cedar Point, Ohio, and concluded that "the frog's food consists of almost any kind of an animal small enough to be seized and swallowed. It has an instinct to snap at all moving objects that come sufficiently near, and will not take dead or motionless animals. Only living and moving creatures are devoured. The frog's tongue is the only organ used for seizing food. . . . Since the greater number of stomachs contained no sand, and since it was found only in stomachs containing ground animals, I am inclined to think that its ingestion was merely incidental."

Barbour (1920) made the following observation on *Rana p. sphenocephala* in Florida: "When alarmed while resting on the bank of a stream, or pond, [it] usually turns about and escapes inland with leaping bounds, evidently more afraid of enemies in the water than on the land." Of this species, also in Florida, Carr (1940) wrote, "They are energetic foragers, ranging several hundred yards from their low-ground habitats in search of food. . . . Apparently any moving object which can be swallowed is taken. Several times they have seized the end of my finger when I have touched it to the tip of the snout of an individual blinded by my flashlight. O. C. Van Hyning photographed one in the process of swallowing a Seminole red bat (*Lasiurus seminola*)."

In the stomachs of 91 leopard-frogs from Utah and Idaho Knowlton (1944) found Coleoptera and Orthoptera to be predominant food items. The following additional insect orders were also represented and are here listed in the order of their frequency:

Diptera, Hemiptera, Lepidoptera, Hymenoptera, Homoptera, Trichoptera.

With respect to *Hyla c. cinerea*, Pope (1919)records having seen one "sitting on top of a stub close to the bayou [Houston, Texas], fast asleep in the daytime." The food in the digestive tract of 100 specimens of this species was examined by Haber (1926); he states that "instinctively the frogs tip and with the tongue strike at almost any object of reasonable (?) size which chances within range. At least some such objects may be set in motion by winds, water-currents, etc., and then may be sufficiently attractive that the frogs strike at them. . . . The Carolina tree-frog, *Hyla cinerea* Schneid., habitually is arboreal, or at least non-aquatic, except during mating and hibernating periods. . . . It is doubtful that this species feeds while mating."

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The Gainesville Region

The area within which this study was made lies in the north-central part of peninsular Florida, in that part of Alachua County adjacent to Gainesville. Alachua County includes parts of three of the physiographic regions into which Florida was divided by

Harper (1914). The region northeast of Gainesville is typical of the East Florida Flatwoods, and has been less disturbed by lumbering and cultivation than have the other two sections. The western and southwestern portions of the county lie in Harper's Peninsular Lime Sink Region; they were originally "high pine land" (Carr, 1940), but the pine was nearly all cut off many years ago, and now where the land is not devoted to agriculture much of it has grown up to stands of turkey oak. The remaining central part of Alachua County is in the so-called Middle Florida Hammock Belt, and a few large areas of hammock remain; most of them have given place to farmland, however, so that today the swamps and flatwoods are the chief remaining natural habitats. Harper (*l.c.*) points out that "nearly every area mapped as one type shows streaks or patches of most of the others," and this is true of the three regions represented in Alachua County. Many ponds, swamps, small streams, wet prairies, cypress "bays," and lakes occur throughout the eastern and central parts of the county, where the work here recorded was done; the western section is more elevated and in general very well drained, but has a few small, local aquatic situations.

Collecting Stations: Most of the field work and collecting was done at thirteen stations, selected to represent the principal habitats where the two frogs studied are to be found, and visited again and again throughout the year. All were located within a radius of eight miles from the center of Gainesville; six were to the east and northeast in the vicinity of Newnan's Lake, and in the East Florida Flatwoods district, the remainder in the Hammock Belt and south, west, and northwest of the town. The following types of environment were represented, all of which have been fully described by Carr (1940):

(1) A small, sluggish stream (Hatchet Creek), with alternating pools and shallows, and bordered by flatwoods and swamp; most of the work was done in a marshy, bayou-like drainage ditch.

(2) A larger stream (Prairie Creek), forming the outlet of Newnan's Lake; it is filled with water-hyacinths, and bordered by swampy hammock and cypress.

(3) A small, sand-bottomed creek (Rattlesnake Branch), flowing through a hardwood hammock, and with shrubgrown margins. Here both frogs were scarce, which was surprising in the case of *Hyla c. cinerea*, usually numerous in hammocks.

(4) Grassy roadside ditches containing water and aquatic vegetation, bordered by pine flatwoods; here *Rana p. sphenocephala* was common.

(5) Fluctuating ponds in high pine woods, meadow-bordered in places; the water-level fluctuates greatly, and the margins are widely inundated at times, creating wide expanses of marsh-like conditions where *R. p. sphenocephala* finds much insect food. The deeper, permanent portions contain aquatic plants.

(6) A small, deep pond (Rifle Range Pond), completely covered with floating vegetation and bordered by sedge marsh and hammock; it has since been drained.

(7) The shore of Newnan's Lake, where it is bordered by an extensive cypress and black gum swamp; the lake margins are covered with mats of floating water-hyacinths. At times of high water the swamp is inundated to a distance of half a mile from the shore, but the water-hyacinths are kept out by fringing debris.

(8) A wet "prairie" (Sugar Foot Prairie), marsh-like and typical of extensive areas in this region. At most times it is shallowly covered with water, and it supports a dense vegetation of aquatic and semi-aquatic vegetation; but the water-level fluctuates, and at times it is dry.

(9) A small swampy hammock (Tennis Court Hammock), more open than is natural because of clearing of the marginal undergrowth; a small intermittent stream flows through it.

(10) A climax hardwood hammock (Biology Station at Newnan's Lake), dominated by magnolia, laurel oak, and hackberry, and with moderately heavy herb and shrub undergrowth. The land slopes down to the lake shore, here bordered by a growth of button-bush and young cypress; the edges of the lake are usually covered with a mat of floating water-hyacinths, the width of which varies from a few to several hundred feet, depending on the direction of the wind and the season of the year. At times of low water a muddy shore is exposed.

(11) A very large limestone sink (Devil's Millhopper), 110 feet deep and about 150 yards in diameter at the brim. Surrounded by a dry turkey oak forest, the sink contains a luxuriant mesophytic hammock, and its slopes are densely covered with tall ferns. Numerous small rills arise from springs on the upper slopes and tumble down the steep sides in miniature falls and rapids. At the bottom is a flat area about 20 yards in diameter, across which flows a stream to a subterranean outlet; this flat is partly bare, partly overgrown with grass and tall herbs. *Hyla c. cinerea* is numerous on the herbaceous vegetation of the slopes, and a few *R. p. sphenocephala* were taken in the bottom of the sink, but *Rana clamitans* is more common than the *sphenocephala*.

Methods of Study

Field Observations on Live Frogs.—At frequent intervals throughout the year, and at all hours of the day and night, both species were observed in their natural environments. Daytime observations of *Hyla c. cinerea* are relatively easy to make, because this species tolerates a great deal of noise and movement without being disturbed. On the other hand, very slight movements on the part of the observer during the day will cause *Rana p. sphenocephala* to suspend normal feeding activity. For night observations, it was usually necessary to use artificial light (generally an electric head-light), which, unfortunately, was a disturbing factor. Some observations were made by moonlight, but the data so obtained necessarily lacked detail.

Laboratory Observations on Live Frogs.—Frogs that were kept in aquaria and terraria very soon became accustomed to the noise, light, and movement in the laboratory, and fed on practically anything that moved within reach. Both *Hyla c. cinerea* and *Rana p. sphenocephala* ate avidly the mosquitoes that abounded in the aquarium room. Live earthworms, cockroaches, crickets, ants, beetles, crayfish, and small frogs offered to *Rana p. sphenocephala* were accepted. *Hyla c. cinerea* readily ate termites, ants, mosquitoes, and flies, and occasionally took small beetles and crickets.

Food Studies made on Preserved Specimens.—By far the greatest amount of data and the most accurate quantative and qualitative determinations of food eaten were obtained through the study of large amounts of preserved material. The stomach contents of 676 specimens of *Hyla c. cinerea* and of 497 specimens of *Rana p. sphenocephala* were examined, and detailed records were kept of the morphological condition and circumstances of collection of each of these individuals. The methods employed in this study were as follows.

Collection of material: During the day one frequently finds the nocturnally active *Hyla c. cinerea* hidden in clumps of Spanish moss (*Dendropogon usneoides*), under the bark of trees, and in other small crevices that offer concealment and protection. Equally as often one sees them crouched on tree limbs or on the under surfaces of palm or water-hyacinth leaves. Usually the third eyelid is drawn over the eye during the daytime, and the frog is undisturbed even by the movement of small insects within easy reach, or by noise and movement made by the observer. The inactivity of these tree-frogs, their frequent concealment, and their protective green, gray or brownish coloration, make them difficult to find, but once they are located they are easy to capture. In late afternoon *cinerea* becomes active, and the species can be found during the entire night on the vegetation of lake shores and hammocks.

By contrast, *Rana p. sphenocephala* is very active both by day and by night, and feeds at all hours. Night collecting of this form is facilitated by the use of an electric head-light which produces a strong beam. The beam of light focuses one's attention on a limited area and is reflected by the frog's eyes, so that individuals are easily located at night. As the light apparently blinds them, they are easily captured. During the day it is difficult to collect *sphenocephala;* motionless individuals are hard to see because of their cryptic coloration, and when one approaches at all closely the frogs leap wildly for the nearest water or grassy clump. Often, however, individuals that seek refuge in the water soon reappear at the sur-

face and can then be captured. Those which escape into the grass crouch quietly in the most sheltered spot available and there remain motionless, so that they can be found only after a careful search. A pistol of .22 caliber loaded with shot shells is useful in collecting *sphenocephala* during the day, but not infrequently a startled frog leaps to cover so quickly that no opportunity is given to shoot.

In order to check digestive action and to prevent regurgitation of food, collected frogs were killed immediately by crushing their skulls between thumb and forefinger. No other satisfactory method of killing was found. The specimens were injected with 10% formalin as soon after killing as possible, either in the field or after return to the laboratory, and were then stored in a solution of the same strength. All frogs collected at the same time and place were given a field catalogue number referring to a notebook entry in which were recorded these data, and also the hour at which collected, air temperature, weather conditions, degree of activity of the frogs, and any other information that seemed pertinent.

Examination of specimens and stomach contents.—At the time of its examination each individual of each lot was assigned an individual number appended to its lot number, and the data concerning it were recorded on a card bearing the compound serial number thus formed. On this card were recorded body length (tip of snout to juncture of thighs), sex (determined from gonads), stomach length (esophageal constriction to pylorus), stomach width (where greatest), size of fat-bodies (in terms of five size groups from extremely small to very large), and condition of gonads. The testes were measured in length and breadth. The ovaries were classified as belonging to one of the following categories: (1) Ovary small, no egg mass visible; (2) egg mass small, eggs not pigmented, 0.1-0.4 mm (*cinerea*), 0.1-05 mm. (*sphenocephala*); (3) egg mass about one-half developed, eggs heavily pigmented, 0.4-0.9 mm (*cinerea*), 0.3-0.9 mm (*sphenocephala*); (4) egg mass almost fully developed, oviduct not swollen, eggs 0.8-1.0 mm (*cinerea*), 0.9-1.5 mm (*sphenocephala*); (5) egg mass fully developed, oviduct swollen along almost its entire length, eggs 1.0-1.3 mm (*cinerea*), 1.3-1.8 mm (*sphenocephala*).

Immediately following the recording of these data, the stomach was removed and split along its greater curvature, and the contents were removed, placed in a watch glass, covered with alcohol, and examined under the binocular microscope. The most easily identified material was then recorded, and the remainder sorted into separate vials for reference to specialists in the various taxonomic groups represented. The serial number of the specimen was placed

in each vial, and when the identifications were received from the specialists they were recorded on the specimen card.

Analysis of the data thus obtained has yielded information on the life cycles of these two species in the Gainesville area, as well as on their food habits. The results of field observations and examination of specimens are summarized in what follows.

The Southern Leopard-Frog
Rana pipiens sphenocephala

The southern leopard-frog is predacious and both a diurnal and nocturnal feeder. It eats practically anything small enough to be swallowed that moves within its reach. Hunger and the presence of suitable food seem to be the only important factors in determining when individuals will eat. Small food organisms are taken with the tongue only, but when the prey is too active or too large to be captured by this means, *sphenocephala* seizes it with its mouth and uses both front feet to assist in the swallowing process. The ingestion of sand, bits of bark, small stones, and vegetable matter of all sorts is probably accidental, as was pointed out by Drake (1914). The stomachs of unfed frogs kept in cages in the laboratory never contained any such material, though sand and vegetation were always available in the cages. So far as I know the leopard-frog has never been seen to capture food beneath the surface of the water, but so frequently are fish and immature dragonfly nymphs found in the stomach contents that the occurrence of underwater feeding is not improbable.

The bulk of the food of *sphenocephala* is made up of spiders, beetles, lepidopterous larvae, crickets, and grasshoppers; but many aquatic animals are also eaten, as can be seen by inspection of Tables 1 and 2. According to my observations this frog does not ingest its shed epidermis, which is of interest since Knowlton (1944) found freshly cast frog skin in the stomachs of six specimens of a closely allied western form of *Rana pipiens*. The stratum corneum of the epidermis was shed about once in thirty-six hours by *sphenocephala* kept in aquaria in the laboratory.

Rana p. sphenocephala does much of its feeding by day, and since most of my specimens were collected at night, the stomach contents were often found in advanced stages of digestion. This was particularly true of the softer-bodied prey. In order to determine something of the rate of digestion, a number of feeding experiments were made in the laboratory. Ten large individuals of the frog were each fed single specimens of the very heavily sclerotized, rather large beetle, *Passalus cornutus*. Fifteen hours later the frogs

were killed and the condition of the beetles ascertained. In four stomachs the abdomen and head of the beetles had become separated from the prothorax; in one the abdomen was separated from the prothorax; in the other stomachs the beetles showed very little digestive change. A single earthworm was fed to each of eight frogs, and the stomachs were examined ten hours later. The earthworms were all reduced to small bits, attached one to the other by strips of the worm's cuticle, which is evidently very resistant to the action of the frog's digestive juices. Earthworms fed to another lot of five frogs were represented twenty hours later only by bits of cuticle remaining in the stomachs. Thus, if only very soft food were eaten, it seems that the frogs could perhaps digest a stomachfull once a day or in less time; but as very few individuals with full stomachs were collected, and since animals in all stages of digestion were found in most stomachs, it seems almost certain that feeding is a more or less continuous process that depends largely on the availability of food. This is in agreement with field observations.

The largest populations of *Rana p. sphenocephala* are found around those bodies of water having the most luxuriant growth of herbaceous shore vegetation. The protection afforded by the grasses and herbage, and the abundant food available in such situations, are probably the chief factors that determine this choice of habitat. In the aquatic and semi-aquatic habitats frequented by this frog, the relative humidity is usually sufficiently high to permit daytime activity without danger of excessive evaporation from the frog's moist skin. At night, when the humidity is everywhere high, they often forage at some distance from the water; and on warm humid nights of the rainy summer season *sphenocephala* wanders so far afield that specimens may be almost as numerous on the highways as around the ponds. Temperature is also an important factor in determining the activity of the southern leopard-frog. When the temperature goes below 50-55° F. this species becomes inactive, and if cold weather prevails for more than a day or so the frog hibernates until the temperature again rises to 60° or 70° F. Hibernation is either in soil along the shore or in the mud at the bottoms of ponds and streams. Individuals have been found during the winter in both types of situation. Hibernating frogs invariably had in their stomachs a soft, glutinous, mucous-like mass of material.

The southern leopard-frog breeds in the Gainesville region in every month of the year. There are, however, two pronounced maxima of breeding, one during January, the other during June and July; the latter involves many more individuals than the former.

Local weather conditions apparently play a large part in determining the time and duration of each of these major breeding seasons. Tadpoles of this species can be found at almost any time of the year, and as transformation usually takes place about 90 days after hatching, the presence and size of the tadpoles furnish some indication of the time of breeding. That this is not an infallible method of estimate is, however, shown by the following experience. Of 400 larvae hatched from eggs in the laboratory on May 22, 1935, all but two transformed at the end of three months. These two larvae remained in the aquarium until March 6 of the following year before undergoing metamorphosis—a period of 268 instead of the usual 90 days. Both the tadpoles and the young frogs appeared normal.

Whether feeding ceases during amplexus is uncertain. Only two pairs of mating individuals were captured; the stomachs of three of these individuals were empty, but that of the fourth, a male, contained one well-digested caterpillar, one march-treader (*Hydrometra martinii*), one juvenile cricket (*Gryllulus assimilis*), and one phalangid (*Leiobunum* sp.). These arthropods may have been eaten before amplexus began.

The Green Tree-Frog
Hyla cinerea cinerea

This species is a crepuscular and nocturnal feeder, inactive during the daylight hours. Its stomach contents include few insects that are diurnal in habit. Most of its insect prey consists of species of the shrub and herb strata, again reflecting its habits, since the frog itself is largely confined to these situations. By far the greatest concentrations of individuals are found in the shrub and herbage zones bordering lakes or ponds, and on the floating rafts of water-hyacinths that are so frequently found in Florida lakes. The low relative humidity that exists during the day is probably one of the chief reasons for the diurnal inactivity of this frog; on days when the humidity is exceptionally high feeding begins much earlier in the afternoon than usual. As with *Rana p. sphenocephala*, both humidity and temperature are important in controlling the activity of *cinerea*. At all temperatures below 40° F. the frog is inactive and in hibernation, and sometimes temperatures only a little below 55° F. will cause it to become inactive. During cold periods the green tree-frog hibernates under the bark of dead trees, under fallen logs and in other protected places. I have never seen any indication of an aquatic hibernation such as was inferred to occur by Haber (1926: 214).

Along the lake margins the basic food organism is the large midge, *Chironomus lobiferus* Say, which is usually abundant and in some years occurs in countless millions.[3] In the frog populations of the hammocks spiders are eaten in greater numbers and constitute a greater portion of the bulk of the food than any other group of animals. The tremendous local populations of both spiders and midges may be responsible for the large size of the *cinerea* population in the Gainesville area. The frogs eat daily, filling the stomach to capacity if possible. The feeding time extends from early dusk until dawn, but under favorable conditions most individuals will have eaten a full meal by 10 P. M. Digestion is usually complete by midafternoon of the following day. The harder parts of some insects take longer to digest, and sometimes they are voided before they are entirely broken up. Tables 1 and 3 show the groups and species of food organisms eaten. The green tree-frog also ingests its shed stratum corneum at frequent intervals—during the warmer parts of the year probably about once a day. From its position in the stomach relative to that of the food materials it would appear that it is swallowed immediately before or just after feeding. In most instances it was the last item swallowed, and it tends to remain in the stomach until the following day.

The breeding season extends from late spring to late summer, limiting dates being about the last of April and the middle of August. The condition of the weather is a controlling factor in determining when, within this period, breeding actually occurs. Little change in the food habits was noted during the breeding period; males appear to eat less than females during this time, but both sexes eat. Numerous mating pairs were taken in which both individuals had recently swallowed spiders, beetles, and midges.

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[3] In such years the abundance of the midge may lead to a spider outbreak along the lake shores, the marginal shrubs and trees becoming swathed in sheets of spider-web. Such an outbreak occurred on the shore of Newnan's Lake in 1931, and was described by Hubbell (*Ann. Ent. Soc. Amer.*, 25(3): 502-4. 1932).

TABLE 1—REPRESENTATION OF TAXONOMIC GROUPS OF FOOD ANIMALS IN TERMS OF THE PERCENTAGE OF THE FOOD-CONTAINING FROG STOMACHS IN WHICH THEY WERE FOUND

Taxonomic Group	*Hyla c. cinerea* % of 497 food-containing stomachs in which found	*Rana p. sphenocephala* % of 443 food-containing stomachs in which found
Mollusca	0.2	7.2
Annelida		6.7
Crustacea		8.3
Scorpionida		0.2
Pseudoscorpionida	0.2	....
Phalangida	0.4	3.2
Araneida	36.9	35.1
Acarina	0.6	0.9
Diplopoda	0.6	3.2
Chilopoda	0.2	1.8
Thysanura		1.0
Collembola	0.2	0.5
Dermaptera		0.2
Orthoptera	4.8	21.9
Neuroptera	0.6	0.2
Odonata	4.6	7.4
Corrodentia	1.0	....
Hemiptera	3.4	13.2
Homoptera	3.0	3.9
Coleoptera	13.0	34.6
Trichoptera		0.2
Lepidoptera (adults)	2.6	8.8
Lepidoptera (larvae)	8.1	21.2
Diptera	66.3	15.5
Hymenoptera	12.3	8.8
Vertebrata		8.5

TABLE 2 — THE FOOD OF RANA PIPIENS SPHENOCEPHALA

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Total Number Specimens Eaten
Stomachs examined	6	8	77	48	41	30	31	28	68	99	41	20	497	
Stomachs empty	1	6	6	2	6	3	1	4	7	6	19	2	64	
Containing food	5	2	71	46	35	27	30	24	61	93	22	18	433	12396

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Specimens
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Eaten
MOLLUSCA, Gastropoda (total)	1	..	1	8	3	6	2	3	3	3	1	..	31	39
Pulmonata (undet.)	..	..	..	1	..	..	..	..	..	1	..	..	2	3
Physa sp.	1	..	1	4	3	6	2	3	3	2	..	..	25	30
Lymnaea sp.	..	..	..	2	..	..	..	..	..	..	1	..	3	5
Planorbis sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
ANNELIDA	..	..	..	..	1	5	2	1	2	18	..	..	29	34
CRUSTACEA (total)	1	1	5	1	5	2	3	2	8	4	..	2	36	40
Cypris sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Oniscidae (undet.)	..	..	1	..	..	..	..	..	..	3	..	..	4	4
Hyallela azteca	..	..	1	..	..	..	..	..	..	..	..	..	1	3
Cambarus sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Cambarus pubescens	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Cambarus fallax	..	1	4	1	5	2	3	2	6	1	..	2	27	29
Cambarus troglodytes	1	..	..	..	..	..	..	..	..	..	..	..	1	1
SCORPIONIDA	..	..	..	..	..	..	..	..	..	1	..	..	1	1
PHALANGIDA (total)	..	..	..	..	3	..	1	1	3	3	2	1	14	17
Leiobunum sp.	..	..	..	..	2	..	..	..	..	..	..	..	2	2
Leiobunum aurugineum	..	..	..	..	..	..	..	..	..	..	2	1	3	3
Mesosoma nigrum	..	..	..	..	1	..	1	1	3	3	..	..	9	12
ARANEIDA (total)	1	..	25	26	13	9	7	9	22	27	9	4	152	243
Agalena sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Agalena naevia	..	..	..	..	..	..	..	..	..	..	1	1	2	2
Ariadna bicolor	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Attidae (undet.)	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Chiracanthium inclusum	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Clubiona sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1

Clubiona abbotti	..	..	1	2	1	..	..	..	..	..	..	..	4	4
Clubiona tibialis	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Cyphosa sericata	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Dolomedes sp.	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Dolomedes scriptus	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Dolomedes triton	..	..	7	2	1	1	2	..	6	..	1	..	20	23
Eperigone sp.	..	..	1	1	..	..	..	..	..	..	..	..	2	2
Eperigone tridentata	..	..	2	..	..	..	..	..	..	..	..	..	2	2
Erigone hydrophytae	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Filistata hibernalis	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Leucauge venusta	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Lycosidae (undet.)	..	..	6	3	3	2	1	..	2	3	..	..	20	21
Lycosa sp.	..	..	1	2	2	..	..	2	1	3	2	..	13	14
Lycosa acompta	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Lycosa carolinensis	..	..	..	..	..	1	..	..	..	..	..	1	2	2
Lycosa helluo	1	..	3	1	1	2	2	1	4	1	2	1	19	22
Lycosa lenta	..	..	..	1	2	..	..	..	..	..	1	2	6	6
Mangora gibberosa	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Micrathena gracilis	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Mimognatha foxi	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Myrmarachne albocinctus	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Neosoma benjamini	..	..	..	..	..	..	..	..	1	1	..	..	2	2
Nephila clavipes	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Paraphidippus marginatus	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Pardosa floridana	..	..	..	..	..	..	..	..	..	2	..	..	2	2
Pardosa milvina	..	..	..	..	..	1	..	..	..	1	..	..	2	2
Phrurotimpus wallacei	..	..	..	..	..	..	..	..	..	1	1	..	2	2
Pirata insularis	..	..	..	3	1	1	..	..	..	1	..	..	6	6
Schizocosa crassipes	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Schizocosa floridana	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Tetragnatha sp.	..	..	1	3	1	..	2	3	2	2	..	..	14	15
Tetragnatha elongata	..	..	..	..	..	..	..	1	5	..	..	..	6	13
Tetragnatha extensa	..	..	..	1	..	..	..	1	1	..	..	..	3	3
Tetragnatha laboriosa	..	..	1	..	..	..	1	1	1	..	..	..	4	6
Tetragnatha pallescens	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Thanatidius dubius	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Trachelas laticeps	..	..	..	..	..	..	..	..	..	..	1	..	1	1

TABLE 2—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Zygoballus bettini	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Other spiders[4]	..	..	4	3	5	3	..	..	2	7	..	..	24	77
ACARINA	..	..	..	3	..	..	..	..	..	1	..	..	4	6
DIPLOPODA	..	..	2	3	1	2	..	..	1	3	2	..	14	17
CHILOPODA	..	..	2	1	1	1	..	..	..	3	..	..	8	8
THYSANURA, *Lepisma* sp.	..	..	1	2	..	..	..	..	..	1	1	..	5	5
COLLEMBOLA (undet.)[5]	..	..	1	1	..	..	..	..	..	..	..	..	2	7
Isotoma sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Podura sp.	..	..	11	2	1	..	..	..	..	2	..	..	16	39
DERMAPTERA, *Labidura riparia*	..	..	1	..	..	..	..	..	..	..	..	..	1	1
ORTHOPTERA (total)	..	..	2	7	8	1	3	5	13	37	12	7	95	154
Blattidae (total)	..	..	..	1	1	..	..	..	1	2	1	1	7	7
Cariblatta l. lutea	..	..	..	1	1	..	..	..	1	2	..	..	5	5
Eurycotis floridana	..	..	..	..	..	..	..	..	..	..	1	1	2	2
Mantidae, *Oligonyx scudderi*	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Tettigoniidae (total)	..	..	1	..	1	..	..	..	2	9	3	1	19	19
Scudderia texensis	..	..	..	..	..	..	..	..	..	..	1	1	2	2
Neoconocephalus sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Neoconocephalus retusus	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Neoconocephalus triops	..	..	1	..	..	..	..	..	..	1	..	..	2	2
Belocephalus s. subapterus	..	..	..	..	..	..	..	..	..	2	1	..	3	3
Orchelimum sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Orchelimum (agile ?)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Orchelimum pulchellum	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Orchelimum militare	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Conocephalus sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Conocephalus f. fasciatus	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Conocephalus brevipennis	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Odontoxiphidium apterum	..	..	..	..	1	..	..	..	1	1	..	..	3	3
Gryllidae (total)	..	..	1	4	5	1	2	1	6	11	4	1	36	39
Gryllotalpa hexadactyla	..	..	..	..	1	..	..	..	..	..	..	..		1
Nemobius sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	1

Nemobius fasciatus socius							1		2				3	3
Nemobius ambitiosus				1									1	1
Nemobius cubensis										1			1	1
Nemobius c. carolinus				2	1					1			4	4
Gryllulus assimilis					2				1				3	3
Gryllulus assimilis variant *luctuosus*			1								1	1	3	3
Gryllulus assimilis variant *firmus*						1	1		1				3	3
Miogryllus verticalis										1	1		2	2
Anaxipha sp.									1				1	1
Hapithus agitator quadratus								1	1	2			4	5
Orocharis saltator									1	2			3	3
Cycloptilum trigonipalpum										3	2		5	6
Cycloptilum bidens										1			1	1
Tridactylidae, *Tridactylus minutus*				1									1	1
Acrididae (total)				1		1	3	4	9	16	6	5	45	75
Syrbula admirabilis										1			1	2
Orphulella pelidna										1			1	1
Dichromorpha viridis						1	5	2	8	8	4	5	33	43
Clinocephalus elegans									2				2	2
Chortophaga australior											1		1	1
Leptysma marginicollis											1		1	1
Melanoplus sp.										1			1	1
Paroxya a. atlantica				1			1	2	3				7	9
Aptenopedes sphenarioides apalachee								2	1	4	2	1	10	12
Aptenopedes aptera borealis										1			1	1
Other Acrididae (undet.)									1	1			2	2
Tetrigidae (total)				1	2				1	6			10	11
Neotettix femoratus										1			1	1
Neotettix bolteri					1					1			2	2
Paratettix sp.									1				1	1
Tettigidea l. lateralis				1						3			4	5
Tettigidea armata					1					1			2	2
NEUROPTERA, Sialidae, *Chauliodes* sp.									1				1	1

[4] 50 of these newly hatched.

[5] 19 frogs ate 47 Collembola.

TABLE 2—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
ODONATA (total)[6,7]	..	..	11	3	..	1	4	3	7	3	..	..	32	32
Anisoptera (total)	..	..	9	2	..	1	3	3	6	2	..	..	26	26
Cordulegaster sp.[6]	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Tetragoneuria sp.[6]	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Libellulinae[7] (undet.)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Erythrodiplax sp.[7]	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Libellula sp.[6]	..	..	5	..	..	1	..	..	..	..	..	..	6	6
Plathemis lydia[6]	..	..	2	..	..	..	..	2	..	..	..	..	4	4
Pachydiplax sp.[6]	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Pachydiplax longipennis[6,7]	..	..	..	1	..	1	..	1	..	1	..	..	4	4
Erythemis simplicicollis[6,7]	..	..	..	1	..	..	3	..	4	..	..	..	8	8
Zygoptera (total)[6,7]	..	..	2	1	..	..	1	..	1	1	..	..	6	6
Telebasis salva[7]	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Enallagma sp.[6]	..	..	1	..	..	..	1	..	1	..	..	..	3	3
Enallagma laurenti[7]	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Ischnura (?) sp.[7]	..	..	..	1	..	..	..	..	..	..	..	..	1	1
CORRODENTIA, Psocidae	..	..	..	1	..	..	..	..	1	..	1	..	3	4
HEMIPTERA (total)	..	..	3	6	3	3	2	3	14	18	3	2	57	67
Pentatomidae (total)	..	..	..	1	..	1	2	1	9	4	2	2	22	22
Mormidea lugens	..	..	..	..	..	..	2	..	3	..	1	1	7	7
Solubea pugnax	..	..	..	..	..	1	..	..	1	..	..	..	2	2
Euschistus sp.	..	..	..	1	..	..	..	..	..	1	..	..	2	2
Euschistus t. tristigmus	..	..	..	..	..	..	..	1	..	..	..	..	1	1
Euschistus tristigmus pyrrocerus	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Euschistus ictericus	..	..	..	..	..	..	..	..	2	..	..	..	2	2
Piezodorus guildinii	..	..	..	..	..	..	..	..	..	..	1	1	2	2
Alcaeorrhynchus grandis	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Other Pentatomidae (undet.)	..	..	..	..	..	..	..	..	3	1	..	..	4	4
Coreidae, *Leptoglossus phyllopus*	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Aradidae, *Mezira granulata*	..	..	..	..	..	..	..	..	..	2	..	..	2	4
Lygaeidae (total)	..	..	1	2	..	2	1	1	..	1	..	..	8	10
Heraeus plebejus	..	..	1	..	..	1	..	..	..	1	..	..	3	3

Orthaea vincta	..	..	..	2	..	1	1	1	..	..	..	..	5	7
Reduviidae (total)	..	..	..	..	2	1	..	1	2	2	..	..	8	8
Emesa sp.	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Emesa brevipennis	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Stenopoda cinerea	..	..	..	..	..	..	..	..	..	2	..	..	2	2
Fitchia spinosula	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Other Reduviidae (undet.)	..	..	..	..	1	..	..	1	1	..	..	..	3	3
Hebridae, *Merragata brunnea*	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Mesoveliidae, *Mesovelia* sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Anthocoridae, *Lasiochilus pallidus*	..	..	..	..	..	..	..	..	..	..	..	..	2	2
Miridae	..	..	..	1	..	..	..	..		..	..	..	1	1
Hydrometridae, *Hydrometra martini*	..	..	..	..	1	..	..	..	1	1	..	..	3	3
Veliidae, *Microvelia* (*hinei*?)	..	..	1	..	..	..	..	..	1	..	..	..	2	2
Naucoridae, *Pelocoris carolinensis*	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Belostomatidae, *Benacus griseus*	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Corixidae, *Corixa* sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	2
Other Hemiptera (undet.)	..	..	..	1	..	..	..	1	2	3	1	..	8	8
HOMOPTERA (total)	1	..	7	1	1	..	..	1	1	5	..	..	17	20
Cercopidae	..	..	..	..	..	..	..	..	1	..	..	..	1	2
Membracidae	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Cicadellidae (total)	..	..	6	1	..	..	..	1	1	3	..	..	12	14
Deltocephalus nigrifrons	..	..	..	..	..	..	..	1	1	..	..	..	2	2
Other Cicadellidae (undet.)	..	..	6	1	..	..	..	..	..	3	..	..	10	12
Aphididae	1	..	1	..	..	..	..	..	..	..	..	..	2	2
Other Homoptera (undet.)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
COLEOPTERA (total)	..	1	37	21	10	8	3	2	20	34	10	4	150	250
Cicindelidae, *Cicindela punctata*	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Carabidae (total)	..	..	6	6	2	2	2	2	12	4	4	2	42	61
Cychrus (?) sp.	..	..	..	..	..	..	1	..	1	..	..	..	2	2
Pasimachus sp.	..	..	..	..	..	..	..	..	1	1	..	..	2	2
Scarites subterraneus	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Clivinia sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Ardistomis sp.	..	..	..	..	..	..	..	1	1	..	..	..	2	9
Amara sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Chlaenius sp.	..	..	..	..	..	..	1	..	2	..	..	..	3	4

[6] Nymphs.
[7] Adults.

TABLE 2—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Stenolophus sp.	..	..	..	1	..	1	..	..	1	..	..	..	3	3
Other Carabidae (undet.)	..	..	5	4	2	1	1	1	5	3	4	2	28	37
Omophronidae (total)	..	..	2	..	..	..	..	..	2	1	..	..	5	6
Omophron sp.	..	..	2	..	..	..	..	..	2	..	..	..	4	4
Omophron labiatum	..	..	..	..	..	..	..	..	..	1	..	..	1	2
Haliplidae, *Peltodytes* sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Dytiscidae (total)	..	..	..	2	..	..	..	..	..	3	..	..	5	5
Bidessus sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Matus bicarinatus	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Coptotomus interrogatus	..	..	..	..	..	..	..	1	..	..	..	..	1	1
Cybister olivieri	..	..	..	..	..	..	..	1	..	..	..	..	1	1
Other Dytiscidae (undet.)	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Gyrinidae, *Dineutes* sp.	..	..	..	1	..	..	..	..	1	..	..	..	2	2
Hydrophilidae (total)	..	..	7	2	1	1	1	..	2	3	..	..	17	21
Berosus sp.	..	..	3	..	..	..	..	..	..	..	..	..	3	5
Hydrophilus castus	..	..	..	..	..	..	1	..	1	..	..	..	2	3
Tropisternus sp.	..	..	2	..	1	..	..	..	..	2	..	..	5	6
Tropisternus glaber	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Tropisternus lateralis	..	..	..	..	..	1	..	..	1	..	..	..	2	2
Enochrus sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other Hydrophilidae (undet.)	..	..	1	1	..	..	..	..	..	1	..	..	3	3
Sphaeridiidae (total)	..	..	..	2	1	..	..	..	..	1	..	..	4	4
Phenotypus (palmarum?)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Cercyon sp.	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Other Sphaeridiidae (undet.)	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Staphilinidae (total)	..	..	1	3	..	..	..	..	..	3	..	..	7	9
Sternus sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Philonthus sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Other Staphilinidae (undet.)	..	..	1	3	..	..	..	..	..	1	..	..	5	7
Cantharidae, *Chauliognathus marginatus*	..	..	..	..	..	..	..	..	..	1	..	..	1	2
Cleridae	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Meloidae, *Macrobasis unicolor*	..	..	..	..	..	..	..	..	2	..	..	..	2	2

Anthicidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Elateridae (total)	..	..	..	..	..	..	..	..	1	5	..	..	6	7
Ludius sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Other Elateridae (undet.)	..	..	..	..	..	..	..	..	1	4	..	..	5	6
Heteroceridae, *Heterocerus* sp.	..	..	2	..	..	..	..	..	..	..	..	..	2	2
Georyssidae	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Dascillidae, *Ptilodactyla* sp.	..	..	2	1	..	..	..	..	..	..	..	..	3	3
Chelonariidae, *Chelonarium lecontei*	..	..	6	1	..	..	..	..	..	..	..	..	7	7
Tenebrionidae (total)	..	..	..	..	2	1	..	..	..	1	..	..	4	4
Opatrinus aciculatus	..	..	..	..	1	..	..	..	..	1	..	..	2	2
Other Tenebrionidae (undet.)	..	..	..	..	1	1	..	..	..	..	..	..	2	2
Ptinidae	..	..	..	..	..	..	..	..	..	1	..	..	1	3
Scarabaeidae (total)	..	..	2	..	1	..	..	..	1	2	..	..	6	9
Aphodius sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Aphodius lividus	..	..	..	..	1	..	..	..	..	1	..	..	2	4
Aphodius vestiarius	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Geotrupes egeriei	..	..	..	..	..	..	..	..	..	1	..	..	1	2
Anomala undulata	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Passalidae, *Passalus cornutus*	..	..	..	..	..	1	..	..	..	..	..	..	1	2
Cerambycidae	..	..	..	1	1	..	..	..	..	..	..	..	2	4
Chrysomelidae (total)	..	..	..	..	1	1	..	..	2	2	..	..	6	6
Diabrotica sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Diabrotica duodecim-punctata	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Anoplitis sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Other Chrysomelidae (undet.)	..	..	..	..	..	..	..	..	1	2	..	..	3	3
Brentidae, *Eupsalis minuta*	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Curculionidae (total)	..	1	12	1	4	..	..	..	2	7	2	..	29	49
Rhodobaenus sp.	..	..	..	..	..	..	..	..	..	1	1	..	2	4
Other Curculionidae (undet.)	..	1	12	1	4	..	..	..	2	6	1	..	27	45
Other Coleoptera (undet.)	..	..	4	5	1	2	..	..	2	11	7	2	34	36
TRICHOPTERA	..	..	..	1	..	..	..	..	1	..	..	..	2	2
LEPIDOPTERA: Adults (total)	1	..	9	5	1		3	..	7	7	3	2	38	40
Tineidae	1	..	..	..	..			..	..				1	1
Pyralididae, *Nymphala* sp.		..	..	..	1	..	1	..	1	..	..	..	3	3
Other Heterocera (undet.)	..	..	9	3	..	..	2	..	5	7	3	2	31	33
Geometridae	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Hesperiidae, *Eudamus proteus*	..	..	..	..	..	..	..	..	1	..	..	..	1	1

TABLE 2—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
LEPIDOPTERA: Larvae (total)	1	..	6	9	4	4	7	5	22	24	8	2	92	151
Pyromorphidae	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Pyralididae, *Nymphala* sp.		..	..	..	..	..	2	1	3	..	1	..	7	23
Other Pyralidid larvae (undet.)	..	..	..	..	..	..	..	..	3	..	..	..	3	6
Sphingidae	..	..	..	..	..	..	..	..	..	..	2	..	2	2
Geometridae	..	..	..	2	..	..	..	..	1	..	..	..	3	3
Noctuidae	..	..	..	..	..	..	..	..	..	7	..	..	7	8
Arctiidae, *Utetheisa bella*			..	1	..	..	..	..	..	..			1	1
Saturniidae	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Nymphalidae	..	..	..	..	..	..	..	..	6	..	..	..	6	7
Other Lepidopterous larvae (undet.)	1	..	6	6	4	4	6	4	10	17	4	2	64	99
DIPTERA (total)	1	..	12	17	5	2	..	1	8	18	3	..	67	116
Tipulidae (total)	1	..	1	9	1	1	..	..	1	6	..	..	20	33
Tipula sp.	1	..	..	..	..	..	..	..	..	..	..	..	1	1
Tipula subeluta	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Tipula tricolor	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Brachypremna dispellans	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Megistocera longipennis	..	..	..	..	..	1	..	..	..	1	..	..	2	2
Limonia (Dicranomyia) sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Limonia (Dicranomyia) distans	1	..	..	1	..	..	..	..	..	..	..	..	2	5
Limonia (Geranomyia) canadensis	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Limonia (Geranomyia) rostrata (?)	..	..	..		..	1	..	..	..	..	..	..	1	1
Pseudolimnophila contempta	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Pseudolimnophila luteipennis	..	..	..	1	1	..	..	..	..	..	..	..	2	5
Limnophila epimicta	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Pilaria recondita	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Gonomya sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Gonomya pleuralis	..	..	..	..	..	..	..	..	1	1	..	..	2	2
Gonomya puer	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Erioptera sp.	..	..	..	..	..	..	..	..	..	2	..	..	2	2
Erioptera caloptera	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Erioptera parva	..	..	..	..	..	..	..	..	..	1	..	..	1	1

Culicidae	..	..	..	1	1	..	..	..	..	..	1	..	3	3
Chironomidae (total)	..	..	9	3	4	1	..	1	2	4	2	..	28	48
Chironomus lobiferus	..	..	6	3	3	1	..	1	1	4	2	..	23	43
Other Chironomidae (undet.)	..	..	3	..	1	..	..	..	1	..	..	..	5	5
Cecidomyiidae	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Mycetophilidae (total)	..	..	..	5	..	..	..	..	..	1	..	..	6	9
Sciara sp.	..	..	..	3	..	..	..	..	..	..	..	..	3	3
Other Mycetophilidae (undet.)	..	..	..	2	..	..	..	..	..	1	..	..	3	6
Tabanidae, *Chrysops* sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Dolichopodidae	..	..	3	..	..	..	..	..	..	1	..	..	4	4
Syrphidae	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Otitidae (Ortalidae)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Trypetidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Drosophilidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Muscidae	..	..	..	2	..	..	..	..	..	1	1	..	4	4
Metopiidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Tachinidae (larval)[8]	..	..	..	..	..	..	..	..	..	1	..	..	1	2
Other Diptera (undet.)	..	..	..	3	..	..	..	..	3	..	..	..	6	7
HYMENOPTERA (total)	1	..	2	6	4	1	1	1	6	12	4	..	38	82
Tenthredinidae, Selandriinae	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Braconidae	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Ichneumonidae (total)	..	..	..	..	1	..	..	..	1	1	..	..	3	3
Ophion sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Other Ichneumonidae (undet.)	..	..	..	..	1	..	..	..	..	1	..	..	2	2
Formicidae (total)	1	..	1	5	1	1	..	1	2	9	4	..	25	43
Ponera sp. (*opaciceps*?)	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Odontomachus sp. (*haematodes*?)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Aphaenogaster sp.	..	..	..	2	..	..	..	..	..	..	1	..	2	2
Other Myrmycinae	..	..	..	1	..	..	..	..	1	6	1	..	9	24
Camponotus sp.	1	..	1	1	..	..	..	..	1	..	1	..	5	5
Camponotus (*Colobopsis*) sp.	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Other Formicidae (undet.)	..	..	..	..	..	1	..	1	..	2	..	..	4	5
Trypoxylonidae, *Trypoxylon* sp.	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Andrenidae	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Apidae, *Apis mellifica*	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Other Hymenoptera (undet.)	..	..	..	..	1	..	1	..	1	2	..	..	5	5

[8] Probably parasitic in an Orthopteran insect which was in the stomach.

TABLE 2—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
VERTEBRATA (total)	..	..	5	1	6	6	2	2	9	2	1	3	37	61
Fishes (total)	..	..	..	1	6	4	2	1	8	..	..	..	22	46
Aphredoderus sayanus	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Ameiuridae (Catfishes)	..	..	..	..	..	1	..	..	1	..	..	..	2	2
Fundulus chrysotus	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Gambusia affinis holbrookii	..	..	..	..	2	3	2	1	7	..	..	..	15	33
Jordanella floridae	..	..	..	..	..	..	..	..	1	..	..	..	1	2
Notemigonus crysoleucas bosci	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Very small sunfishes and minnows	..	..	..	1	4	..	..	..	..	..	..	..	5	5
Salamanders, *Desmognathus fuscus*	..	..	..	..	..	..	..	..	1	..	..	..	1	1
Frogs (total)	..	..	5	..	..	2	..	1	..	2	1	3	14	14
Acris gryllus	..	..	1	..	..	1	..	..	..	..	..	3	5	5
Hyla cinerea cinerea	..	..	1	..	..	1	..	1	..	..	..	..	3	3
Rana pipiens sphenocephala	..	..	1	..	..	..	..	..	..	1	1	..	3	3
Other frogs (undet.)	..	..	2	..	..	..	..	..	..	1	..	..	3	3
Other vertebrates (undet.)	..	..	..	..	..	..	..	..	1	..	..	..	1	1

TABLE 3 — THE FOOD OF HYLA CINEREA CINEREA

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Total Number Specimens Eaten
Stomachs examined	21	25	98	124	123	48	25	29	1	99	79	4	676	
Stomachs empty	12	11	14	6	5	1	0	3	0	5	5	2	64	
Containing only stratum corneum	9	10	9	38	15	2	0	2	1	21	7	1	115	
Containing food organisms	0	4	75	80	103	45	25	24	0	73	67	1	497	6,793

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	ul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
MOLLUSCA, Limacidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
PSEUDOSCORPIONIDA	..	..	..	..	1	..	..	..	..	..	..	..	1	1
PHALANGIDA (total)	..	..	1	1	..	..	1	..	..	..	..	..	3	3
Mesosoma nigrum	..	..	..	1	..	..	1	..	..	..	..	..	2	2
Libitioides sayi	..	..	1	..	..	..	..	..	..	..	..	..	1	1
ARANEIDA (total)	..	..	22	20	51	21	1	7	..	38	23	..	183	269
Agalena sp.	..	..	..	2	1	..	..	..	..	1	..	..	4	5
Anyphaena laticeps	..	..	..	..	2	..	..	..	..	1	..	..	3	3
Anyphaenella albens	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Aranea sp.	..	..	..	..	4	..	..	..	..	..	..	..	4	4
Aranea foliata	..	..	..	..	..	2	..	..	..	..	..	..	2	2
Argiopidae (undet.)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Argyrodes sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Argyrodes cancellatus	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Aysha velox	..	..	..	..	2	..	..	..	..	..	..	..	2	2
Clubiona sp.	..	..	1	..	3	1	..	..	..	1	1	..	7	7
Clubiona abotti	..	..	..	1	1	3	..	..	..	..	..	1	6	7
Clubiona pallens	..	..	1	..	1	..	..	..	..	..	..	..	2	2
Clubiona tibialis	..	..	..	1	2	2	..	..	..	1	..	..	6	6
Dictyna rubra	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Dinopis spinosa	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Dolomedes sp.	..	..	..	..	2	2	..	..	..	2	..	..	6	7

TABLE 3—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Dolomedes triton	..	..	1	1	2	1	..	2	..	3	1	..	11	11
Erigone hydrophytae	..	..	..	..	2	..	..	..	..	..	..	..	2	2
Eustala anastera	..	..	1	..	10	1	..	..	..	..	..	..	12	20
Grammonota texana	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Leucauge venusta	..	..	..	..	3	..	..	..	..	..	..	..	3	5
Lycosidae (undet.)	..	..	..	..	5	..	..	..	..	1	..	..	6	6
Lycosa sp.	..	..	..	1	2	1	..	..	..	1	1	..	6	6
Lycosa helluo	..	..	..	..	..	..	..	1	..	..	1	..	2	2
Metaphidippus capitatus	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Metazygia incerta	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Metazygia wittfeldae	..	..	8	..	12	11	..	3	..	12	9	..	55	69
Neoscona arabesca	..	..	..	..	2	..	..	..	..	..	..	..	1	1
Pardosa sp.	..	..	..	..	1	..	..	..	..	1	..	..	2	2
Pelopatis undulata	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Peucetia viridans	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Philodromus barrowsi	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Pirata insularis	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Tetragnatha sp.	..	..	2	3	7	3	..	..	..	6	1	..	22	24
Tetragnatha elongata	..	..	..	4	6	2	..	1	..	1	3	..	17	20
Tetragnatha extensa	..	..	..	..	2	..	..	1	..	..	..	..	3	5
Tetragnatha laboriosa	..	..	1	..	1	..	..	..	..	1	..	..	3	3
Tetragnatha lacerta	..	..	..	..	..	..	..	1	..	..	1	..	2	2
Tetragnatha pallescens	..	..	..	1	1	..	..	..	..	..	..	..	2	2
Tetragnatha seneca	..	..	..	4	7	6	..	1	..	1	2	..	21	36
Trachelas laticeps	..	..	..	1	1	..	..	..	..	..	1	..	3	3
Uloborus americanus	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Xysticus sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other spiders (undet.)	..	..	6	4	2	2	..	..	..	9	2	..	25	29
ACARINA	..	..	..	3	..	..	..	..	..	..	..	..	3	9
DIPLOPODA	..	..	..	1	..	..	..	..	..	2	..	..	3	3
CHILOPODA	..	..	1	..	..	..	..	..	..	..	..	..	1	1

COLLEMBOLA	..	..	1	..	..	..	..	..	..	..	..	..	1	1
ORTHOPTERA (total)	..	..	2	3	13	1	..	..	..	3	..	..	22	24
Blattidae, *Cariblatta l. lutea*	..	..	1	..	3	..	..	..	..	..	..	..	4	5
Mantidae, *Stagmomantis carolina*	..	..	..	..	2	..	..	..	..	..	..	..	2	2
Gryllacrididae, *Camptonotus carolinensis*	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Tettigoniidae (total)	..	..	1	1	2	..	..	..	..	2	..	..	6	6
Neoconocephalus (caudellianus?)	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Orchelimum pulchellum	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Conocephalus sp.	..	..	..	1	1	..	..	..	..	..	..	..	2	2
Conocephalus f. fasciatus	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Other Tettigoniidae (undet.)	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Gryllidae (total)	..	..	..	2	2	..	..	..	..	1	..	..	5	6
Gryllotalpa hexadactyla	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Nemobius ambitiosus	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Hapithus agitator quadratus	..	..	..	..	2	..	..	..	..	1	..	..	3	4
Acrididae, *Dichromorpha viridis*	..	..	..	..	2	1	..	..	..	..	..	..	3	3
Tetrigidae, *Tettigidea l. lateralis*	..	..	..	..	1	..	..	..	..	..	..	..	1	1
NEUROPTERA (total)	..	1	..	..	1	..	..	..	..	1	..	..	3	3
Myrmeleonidae (adults)	..	1	..	..	1	..	..	..	..	..	..	..	2	2
Other Neuroptera (nymph)	..	..	..	..	..	..	..	..	..	1	..	..	1	1
ODONATA (total)[9]	..	..	1	6	8	1	..	..	..	7	..	..	23	23
Anisoptera (total)[9]	..	..	..	5	6	1	..	..	..	..	..	..	12	12
Libellulinae (undet.)[10]	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Perithemis seminole[11]	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Brachymesia gravida[12]	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Pachydiplax sp. (?)	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Pachydiplax longipennis[13]	..	..	..	1	4	1	..	..	..	..	..	..	6	6
Erythemis simplicicollis[14]	..	..	..	1	1	..	..	..	..	..	..	..	2	2
Zygoptera (total)	..	..	1	1	2	..	..	..	..	7	..	..	11	11
Lestes sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Ischnura posita	..	..	1	1	1	..	..	..	..	7	..	..	10	10

[9] All adults except one nymph.
[10] Taken just as it emerged.
[11] Cast nymphal skin.
[12] Cast nymphal skin and adult.
[13] One specimen teneral.
[14] Nymph and teneral adult.

TABLE 3—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND													Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
CORRODENTIA (total)	..	..	..	3	1	..	..	..	..	1	..	..	5	7
Caecilliidae	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Psocidae	..	..	..	2	1	..	..	..	..	1	..	..	4	6
HEMIPTERA (total)	..	..	4	3	7	1	..	..	..	2	..	..	17	23
Pentatomidae (total)	..	..	1	1	..	1	..	..	..	2	..	..	5	6
Euschistus t. tristigmus	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Euschistus tristigmus pyrrhocerus	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Other Pentatomidae (undet.)	..	..	..	..	..	1	..	..	..	2	..	..	3	4
Coreidae	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Lygaeidae (total)	..	..	..	1	2	..	..	..	..	..	..	..	2	3
Orthaea vincta	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other Lygaeidae (undet.)	..	..	..	..	2	..	..	..	..	..	..	..	2	2
Tingitidae, *Leptophya mutica*	..	..	2	..	1	..	..	..	..	..	..	..	3	5
Reduviidae (total)	..	..	1	..	2	..	..	..	..	..	..	..	3	3
Emesa sp.	..	..	..		1	..	..	..	..		..	..	1	1
Rhiginia cruciata	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Sinea sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Mesoveliidae, *Mesovelia* sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Hydrometridae, *Hydrometra martini*	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other Hemiptera (undet.)	..	..	1	..	..	..	..	..	..	..	..	..	1	1
HOMOPTERA (total)	..	..	4	1	2	1	..	..	..	6	1	..	15	19
Membracidae	..	..	..	..	..	1	..	..	..	..	..	..	1	1
Cicadellidae	..	..	2	1	1	..	..	..	..	2	1	..	7	7
Fulgoridae, Delphacinae	..	..	1	..	..	..	..	..	..	4	..	..	5	7
Aphididae	..	..	1	..	1	..	..	..	..	..	..	..	2	4
COLEOPTERA (total)	..	..	15	17	16	8	..	3	..	5	3	..	66	75
Carabidae	..	..	3	..	..	1	..	1	..	..	..	..	5	5
Hydrophilidae	..	..	..	1	2	..	..	..	..	..	..	..	3	4
Sphaeridiidae	..	..	3	2	..	1	..	..	..	..	..	..	6	9
Staphylinidae	..	..	..	1	..	..	..	..	..	..	..	..	1	3
Cantharidae (total)	..	..	1	1	..	..	..	..	..	..	..	..	2	2
Chauliognathus marginatus	..	..	1	1	..	..	..	..	..	..	..	..	2	2

Trichopterygidae	..	..	..	1	1	..	..	..	..	..	..	..	2	2
Cleridae	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Anthicidae	..	..	..	..	..	..	..	..	..	..	1	..	1	1
Elateridae	..	..	1	..	2	..	..	..	..	2	..	..	5	7
Buprestidae	..	..	..	1	..	..	..	..	..	..	..	..	1	2
Chelonariidae, *Chelonarium lecontei*	..	..	1	..	..	..	..	..	..	..	..	..	1	2
Ostomidae	..	..	..	..	1	..	..	1	..	..	..	..	2	2
Nitidulidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Derodontidae	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Lathridiidae, *Enicmus aterrimus*	..	..	1	..	..	..	..	..	..	..	..	..	1	2
Coccinellidae, *Hippodamia* sp.	..	..	..	1	1	..	..	..	..	..	..	..	2	4
Tenebrionidae	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Scarabaeidae (total)	..	..	1	..	..	2	..	..	..	..	..	..	3	6
Aphodius campestris	..	..	..	..	..	1	..	..	..	..	..	..	1	3
Serica lecontei	..	..	1	..	..	..	..	..	..	..	..	..	1	3
Pachystethus marginatus	..	..	..	..	..	1	..	..	..	..	..	..	1	2
Cerambycidae	..	..	1	..	1	..	..	..	..	..	..	..	2	3
Chrysomelidae (total)	..	..	4	5	3	2	..	..	..	..	2	..	16	23
Donacia sp.	..	..	..	..	..	1	..	..	..	..	..	..	1	3
Cryptocephalus sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Haltica sp.	..	..	..	2	1	..	..	..	..	..	..	..	3	5
Systena sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Longitarsus sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Psylliodes punctata	..	..	..	..	..	..	..	..	..	..	2	..	2	2
Other Chrysomelidae (undet.)	..	..	2	3	1	1	..	..	..	..	..	..	7	10
Curculionidae (total)	..	..	2	3	2	1	..	..	..	1	..	..	9	18
Derelomus basalis[15]	..	..	..	1	..	..	..	..	..	..	..	..	1	2
Platypodidae, *Platipus* sp.	..	..	..	..	1	..	..	..	..	..	..	..	1	2
Scolytidae, *Pityophthorus pulicarius*	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other Coleoptera (undet.)	..	..	5	3	3	..	..	1	..	1	..	..	13	13
LEPIDOPTERA: Adults (total)	..	..	4	1	3	4	..	..	..	1	..	..	13	16
Tineidae	..	..	..	1	..	..	..	..	..	..	..	..	1	2
Noctuidae	..	..	..	..	1	1	..	..	..	..	..	..	2	3
Other Heterocera (undet.)	..	..	3	..	1	3	..	..	..	..	..	..	7	8
Hesperiidae	..	..	1	..	1	..	..	..	..	1	..	..	3	3
LEPIDOPTERA: Larvae (total)	..	..	6	7	7	4	..	3	..	11	2	..	40	50
Geometridae	..	..	..	..	1	..	..	..	..	2	..	..	3	3

[15] Lives in palmetto flowers.

TABLE 3—(Continued)

LIST OF ORGANISMS EATEN	NUMBER OF STOMACHS IN WHICH FOUND												Total	Total Number Specimens Eaten
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov	Dec.		
Nymphalidae, *Basilarchia* sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other Lepidopterous larvae	..	..	6	6	6	4	..	3	..	9	2	..	36	46
DIPTERA (total)	..	..	49	47	56	30	..	23	..	57	67	..	329	6,154
Tipulidae (total)	..	..	..	6	1	..	..	1	..	2	..	..	10	10
Tipula tricolor	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Limonia (Geranomyia) rostrata	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Atarba picticornis	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Pseudolimnophila luteipennis	..	..	..	1	1	..	..	..	..	..	..	..	2	2
Pilaria tenuipes	..	..	..	..	..	..	..	1	..	..	..	..	1	1
Erioptera parva	..	..	..	..	..	..	..	..	..	2	..	..	2	2
Teucholabis lucida	..	..	..	2	..	..	..	..	..	..	..	..	2	2
Dixidae, *Dixa* sp.	..	..	1	..	..	..	..	..	..	..	..	..	1	1
Culicidae (total)	..	..	..	1	..	..	..	..	..	1	..	..	2	2
Aedes sp.	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Anopheles sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Chironomidae (total)	..	..	47	39	54	30	..	22	..	53	67	..	312	6,133
Chironomus lobiferus	..	..	47	39	53	30	..	22	..	51	67	..	309	6,127
Other Chironomidae (undet.)	..	..	..	..	1	..	..	..	..	2	..	..	3	6
Cecidomyiidae	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Mycetophilidae	..	..	1	..	..	..	..	..	..	1	..	..	2	2
Syrphidae	..	..	..	1	1	..	..	..	..	..	..	..	2	2
Trypetidae	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Muscidae	..	..	1	..	..	..	..	..	..	1	..	..	2	2
Other Diptera (undet.)	..	..	1	..	1	..	..	1	..	..	..	..	3	3
HYMENOPTERA (total)	..	..	18	8	13	4	..	2	..	15	..	1	61	102
Chalastogastra (total)	..	..	1	1	..	..	..	1	..	..	..	..	3	3
Tenthredinidae, Selandriinae	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Other Chalastogastra (undet.)	..	..	1	..	..	..	..	1	..	..	..	..	2	2
Clistogastra (total)	..	..	17	7	13	4	..	1	..	15	..	1	58	99
Braconidae	..	..	..	..	..	..	..	..	..	..	..	1	1	1
Ichneumonidae	..	..	1	..	..	..	..	..	..	1	..	..	2	2

Formicidae (total)	..	..	..	15	7	12	4	..	..	..	13	..	51	90
Ponera sp. (*opaciceps?*)	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Monomorium sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Solenopsis sp.	..	..	..	..	..	..	..	..	..	1	..	..	1	1
Aphaenogaster sp.	..	..	..	..	1	..	..	..	..	1	..	..	2	2
Crematogaster sp.	..	..	8	3	5	..	..	..	..	6	..	..	22	47
Other Myrmicinae (undet.)	..	..	2	..	1	..	..	..	..	2	..	..	5	6
Prenolepis (*imparis?*)	..	..	..	1	..	..	..	..	..	..	..	..	1	1
Camponotus sp.	..	..	..	..	3	2	..	..	..	2	..	..	7	7
Other Formicidae (undet.)	..	..	6	2	2	3	..	..	..	2	..	..	15	24
Vespidae, *Polistes* sp.	..	..	..	..	2	..	..	..	..	1	..	..	3	3
Sphecoidea	..	..	..	..	1	..	..	..	..	..	..	..	1	1
Other Clistogastra (undet.)	..	..	1	..	..	..	..	1	..	..	..	..	2	2

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EDUCATION IN THIS AGE OF SCIENCE

A. A. Bless

University of Florida

During the recent elections the Democrats blamed the Republicans for scuttling the League of Nations, and the Republicans, in turn, blamed the Democrats for failure to prepare for war or to prevent it. The surprising part is that the real culprit of these failures, our educational system, was not mentioned at all. Our education has failed to prepare our students for an understanding of the world in which we live. The products of our schools repudiated the League in 1919. The products of our schools allowed a problem of world wide importance to become a football for personal animosities and a victim of injured vanities. It is the product of our schools that permitted the orgies of the 20's and the depression of the 30's.

It is curious, but on analysis not very flattering, that no one is accusing our educators or our educational institutions for the failures of these decades. It is evident that no one is expecting anything from our education and that they get just what they expect.

We are passing through a painful period of readjustment in our thinking and in range of interests. We are ridding ourselves of national isolationism. We are disturbed by the fact that we have a community of interests with the rest of the world. It has taken two world wars to convince us that there is only one world, and that important events on one side of the globe affect the other. The sufferings of people in China, Poland, or Greece, the events in Argentina, are no longer of mere Sunday school interest to us. We are dimly and somewhat painfully realizing that these matters are of vital concern to us, and that they are bound to affect our well being.

It is all the more difficult to adjust our thinking and our range

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of interests to an international scale because of the comparatively recent individual and regional isolationism of the pioneering days. In a primitive community the main effort of the individual is to survive. The business of making a living, of subduing the forces opposing him is most absorbing and takes most of his energy. Whatever is happening in other, far distant communities is of minor concern to him, particularly if the connection between those events and his own well being is not obvious. The business of living, of gaining the daily bread, is much too absorbing to allow him to spend time on political and economic speculations. It is natural for people under such circumstances to develop an attitude of individual or regional isolationism, in the sense that the main business of the individual is to attend to his own business and not to concern himself with the affairs of other people or of other communities and regions.

Our educational institutions are geared, I believe, to this attitude of individual isolationism. The most important duty of the educational institution is to train individuals to be proficient in a given field. The assumption is that the most important business of the individual is to earn his daily bread. The measure of the effectiveness of education is the degree of material success that graduates enjoy. The preponderance of the curriculum is in the direction of the so-called practical subjects—those studies which most effectively prepare the students for the task of earning. While cultural subjects are offered to the students, they are considered as being good only for his soul and occupy a subordinate position. The fact that the graduate is to live in a world full of important problems the solution of which is bound to affect his welfare does not enter at all into the curriculum.

It is hardly debatable that education for personal gain is scant fare for the natural idealism of youth. Such an education gives no sense of realization of our indebtedness to the past, and no sense of obligation to the future. Aside from considerations of ethics or social responsibility this education is wholly unrealistic, wholly out of date. The graduates of our colleges do live in communities. The welfare of the community does affect the welfare of the graduates to a very large extent, and to ignore this is simply nonsensical. The personal competence of the graduate was of little avail in the years of depression. Seemingly through no fault of his own many a competent man has found himself out of a job and unable to provide the necessities of life, the task for which he had been trained in college. Few events in the life of

the individual are so overpowering in their influence on him as World War I and especially the present war. The financial burden of these struggles will be a factor in the life of everyone for generations to come, even if we neglect, which is hardly possible, the thousands of casualties which affect more or less directly every family in this country. The relations among nations in the postwar world are bound to affect the material welfare of this country and of each one of us. For the sake of his own well being, if for no other reason, the graduate must be able to play a significant and intelligent part in social affairs. The part the individual plays in the community and in the affairs of government is all the more significant because of the nature of our government

It is often remarked that our political leadership is of the Gallup poll variety—one that follows very closely the views of the electorate at the moment. This type of "leadership," whatever else may be said of it, increases the importance of the electorate of the voter. Unless the voter is informed, unless he is intelligent enough, the legislation is likely to be blundering and ineffectual. The welfare of our society is thus directly related to the intelligence, wisdom, and thinking of its members; it is related to those traits which form the sum total of education. It is thus directly related to the success (or lack of it) of our educational agencies, particularly our educational institutions.

Unfortunately our college leadership is also more or less of the Gallup poll variety. We shall furnish the desired studies if the students demand it. We shall gladly follow the leadership of students, and, as soon as they have grown up to the realization of the importance of the social world we shall supply the desired curriculum and facilities.

It is idle to expect a recent high school graduate to have enough understanding of the world to effect changes in our curricula. What is more important, the high school student together with his college brother suffers from the notion that education is terminal with graduation from school, and from methods of instruction that do make it terminal.

Recent changes in the secondary school curriculum were based on the fact that few high school graduates go to college. It was assumed that preparation for college and preparation for life were not at all similar, and modifications were made in the course in order to adjust them to the needs of the majority, whose education terminates with graduation, in order to prepare the gra-

uates more adequately for their roles as breadwinners and citizens.

The assumption that formal education ends with graduation from school is based on the belief that the growth of the intellect and the growth of the individual's understanding of questions that concern him ends with graduation. It rests on the idea that schools are the only agents of education. While a person may be influenced by radio, newspapers, books, and associations with fellow men, the contribution of all these factors to his growth is assumed to be so small as to be negligible. Because of this assumption it is natural to regard formal schooling as the exclusive agency of learning, and to cram into the curriculum a great deal of supposedly useful information about many different things.

This attitude is, I believe, quite wrong. It is wrong first because, of necessity, it lays too great a stress on information which in a few short years may become as obsolete as the proverbial dodo. More important, it is wrong because the education of a student does not, or at least need not, stop with school. This process could and should continue through the years, and with many people, it does so.

I do not claim to be a student of Lincoln, but I have read enough to appreciate the fact that Lincoln the President was not Lincoln the Congressman. Very recently we had an example of astonishing growth. I have followed as closely as I could the speeches and the writings of Wendell Willkie from 1938 to 1944. He was placed in a position of great responsibility as the leader of opposition, and his whole mental background responded to that challenge. Willkie of 1944 was of a stature totally different than Willkie of 1938.

This does not mean that the influence of formal education is negligible—far from it. It is the greatest single factor in the development of the student. It may determine whether or not the individual is capable of growing, and may also determine the direction in which the development may proceed.

If this is true it follows that the best high school education—and the best college education for that matter—is such as will enable a student to continue his development later on, to learn from life and become wiser with years. The desirable features of education are therefore not the specific items of information that the student gets from his courses but a certain very definite background—certain attitudes and disciplines. These include:

1. Habits of and capacity for consistent concentrated work. The importance of this is so evident as to need no elaboration. In this connection it is worth mentioning the fact that the so-called comprehensive examinations exert a demoralizing influence if the grade of the student depends entirely on the results of the finals. Basing the whole grade on the final examinations leads to procrastination and to distinctly weaker intellectual efforts. It does not develop responsibility at all as some claim; it gives responsibility, which is an entirely different thing. Few students with the immature background of the high school (few grown-ups, too, for that matter) will do much work many months before the examinations; they postpone most of the studying until shortly before finals. There are few courses worth their salt the contents of which can be adequately mastered in a short time. The mean level of achievement on the examinations is thus bound to be low. If our institutions had the hard-boiled attitude of the continental universities the results of the finals would provide an excellent criterion for eliminating those students who do not have the sense of responsibility and do not study during the year. However, our institutions have an attitude of paternalism and rarely fail as many students as should be failed; we usually "flunk" a "reasonable" percentage. The consequence is that both scholarship and morale suffer. It tends to turn our educational institutions into nice places where nice young men and women have a nice time in nice surroundings under nice instructors, as President Hutchins phrases it, and this is not nice at all. It is a crime against the students and against education.

2. Capacity for and enjoyment of intellectual efforts. Regardless of the amount of information we may be able to give to the student during his secondary and college education, his mind is bound to become sterile unless it continues to receive new ideas and to exert new efforts. To rely on formal education alone for the subsequent intellectual activities of the student is equivalent to relying on a single fertilization for all subsequent crops of a field. Sterility is the only result.

The degree of our failure to develop the capacity for and enjoyment of intellectual effort is shown by a recent poll on the sale of magazines and periodicals to the soldiers. The so-called comics outsold the combined list of periodicals of the type of *Life* and *Time* in a ratio of five to one. A survey in the August, 1944, issue of the *Journal of the Franklin Institute* on the reading habits of leaders in finance and in the professions revealed that

most of the reading of these men was confined to newspapers and to *Life*. The intellectual fare of a large class of graduate students did not rise above the *Saturday Evening Post*.

3. Scientific attitude. It is a truism that we live in an age of science. At no time in our history has the impact of scientific advances been so far-reaching in its importance to us. The advances in technology affect every moment of our existence. The qualities which have made scientific advances possible—objectivity, open-mindedness, and intellectual honesty are completely lacking in the domain of our social relations. The scientific attitude, the scientific point of view is, or seems to be, skin deep. We apply one set of attitudes in our relations with natural phenomena and the inanimate world, and an entirely different set in our relations with our fellow men. The construction or repair of a car or radio set, the preparation of chemicals, the study of biological phenomena—in all these we use objectivity, intelligence, and open-mindedness. In our social relations, in the selection of leaders, in our decisions of matters of national and international policy, we use bigotry, bias, and short-sightedness. If the construction of a bridge or of a plane were undertaken with the qualities we use in our social relations the results would be disastrous and immediate. The results are not better in the domain of social affairs, although they are not so immediate and obvious.

Besides these attitudes, our education must give to the student a basic understanding of the nature of the world in which we live. The nature of our society may be studied from the external manifestations of our social activity—the process which is most often used at present—without the least understanding of the fundamentals underlying this activity; or it may be studied in the spirit proposed by President Hutchins of the University of Chicago. According to President Hutchins, the most important subject of a proper educational program is the study of the nature of man, the nature of human society, the relation of man to religion and to society. Wisdom is ageless; for this reason, the study of Socrates, Plato, Spinoza, and other great philosophers is not a waste of time as is implied by some proponents of modern education who would confine our efforts to the study of the present only. The understanding of the present is possible only in the light of a proper perspective of the past.

President Hutchins is not only advocating certain curricular changes in studies, but also the direction in which these studies

should go. To him the all-important fact is that we live in communities. A community is a body of people that have some interest in common. A society in which one part is thwarting another part, in which one part is doing something which another part is strenuously undoing, it is not a society at all. The idea that the best government is one that governs least is as repugnant to him as the idea that the best society is one in which there is little in common in the ideals and ideas of people. The government is the agent and the expression of the common will, common interest, and common aspiration.

We are now in a very critical period of our history. There seems to be a definite need and a determined desire to create a more reasonable world, a world with some insurance against the repetition of the present catastrophe. We are about to assume world responsibilities, which marks a departure in our history. What are the colleges doing about it? It the reports that are received from colleges are any criterion, we are merely busy refurbishing our shelves and restocking them with articles that our customers, the future students, are likely to require. We are instituting speed-up courses, abbreviated studies, and a course in this and in that, in the hope that we will get more customers into our shops.

There is no attempt to evaluate what it is that we wish as our end product; what it is that the educated American is to know or understand. The problem of future peace, of world relationships, the problem of international economics, international culture, the problem of full employment, of freedom from want and from fear—all these problems find little reflection in our educational plans. All of us are in favor of these things, all of us feel keenly the need for a better world, but we leave the actual job to someone else. What agency outside of education has the power and the obligation to develop a generation of men with the vision to conceive this world, the determination to work for such a world, and the spirit to live in such a world?

We are now debating the desirability of universal military training. There is a definite feeling that, in the world in which we now live, we must be strong if our voice in international affairs is to be effective. I shall not discuss here the merits of military training; I shall merely point out that if a fraction of the proposed efforts were to be used for improving our educational facilities, to rear a generation not afraid of intellectual or physical work, a generation which instead of hiding its head in the

sands of escape literature is willing to face the realities of the day and has the intelligence to do so honestly and objectively, a generation which understands the basic principles on which our society and our system of government rests, I believe the nation would be much stronger than any military program is likely to make it.

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SOME PHILOSOPHICAL IMPLICATIONS OF MODERN SCIENCE

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This century has witnessed certain events in science which have profoundly affected philosophical thinking. These events center in the discovery of illuminating facts with regard to the nature of matter, space, and time.

When Democritus formulated his speculative atomic theory, he set the fashion for years to come of thinking of matter as tiny particles moving in a void. When Euclid synthesized and restated the principles of geometry, he thought of space as an ideal entity, absolute and unmoving, corresponding to this void. Thus in the dawn of science we find an initial conflict, a science resting on the concept of materialism and mathematics resting on the concept of idealism. Matter is substantial and space-filling. Space is an idealistic projection of the mind. This conflict is reflected hundreds of years later in Galileo's formulation of the law of inertia. When the law of inertia asserts that matter remains at rest or moves in a straight line at a uniform rate unless interfered with by some outside force, it confesses that the world of matter must conform to the straight lines drawn only by the mind. When Galileo measured the rate of acceleration of marbles rolling down an inclined plane, he substituted for the Aristotelian concept of time a new and ideal concept of the cosmic sequence of events which was also ideal. Thus the scientists of the Renaissance started the long development of physical science with a system of spacio-temporal measurement of an ideal world which was in direct conflict with the physical world in which we find no straight lines nor cosmic clocks.

Newton attempted to bring these two worlds together with his law of gravitation as it applied to the curvilinear motion of celestial bodies by postulating the existence of a gravitational force which pulled the celestial bodies out of their natural straight-line motion into a curve, the angle of deflection of which represented the rate of acceleration of a freely-falling body. But Newton conceived of this force as operating in a void, and thus the fundamental conflict was not really removed. Another indication of the fact that Newton held this concept is the fact that he held to the corpuscular concept of the propagation of light.

When Young and Fresnel finally forced the science of their day to accept their evidence for a wave theory of the motion of light, the concept of the void was called into question. A wave theory of light demands a waving medium. You cannot have the waving lake without the lake, nor the smile without the cat. Thus was introduced one of the most curious concepts in the history of modern science—the concept of the static luminiferous ether. It was necessary that the ether be a material medium, but it was equally necessary that it should be non-atomic, so the void was filled with a new kind of matter, continuous and non-atomic. But space thus filled was shot through with the atoms of Democritus. This presented a new dilemma—how can atoms move in a continuous substance? The first step in the solution of this dilemma was the obvious one taken by Michelson and Morley. In effect, they attempted to discover whether there was any physical evidence for the existence of the ether. The character and results of this famous experiment are well known. They discovered that there was insufficient physical evidence for the existence of ether, and thus science was thrown back to the concept of the void. FitzGerald and Lorentz attempted to account for the negative results of the Michelson-Morley experiment with the famous FitzGerald-Lorentz contraction hypothesis. This hypothesis is one of the most curious and seemingly contradictory proposals in the history of science. You will remember that it assumes that bodies contract in the direction of their motion and that the contraction is to the amount necessary to account for the negative results of the Michelson-Morley experiment. This contraction is supposed to appear in any body independent of the physical constitution of the body. Mathematically, this was an ideal solution, and the physical world, as in the time of Newton, was wrenched into conformity with the ideal world of the mind. Again, no physical verification of this curious contraction was discovered. Indeed, it was not only practically but also theoretically impossible to do so, because when a measuring rod was placed against a moving body, the measuring rod contracted to exactly the same amount as the moving body. Thus the FitzGerald-Lorentz contraction hypothesis could not be proved or disproved. Mathematicians were allowed to remain in the ivory tower of their own intellectual processes and experimental physicists buried their heads in the sand. The first principles of science were again called into question. The scientists of our era were challenged to remove the conflict in first principles.

They accepted the challenge and re-examined the old concepts of matter, space and time.

It seemed perfectly obvious that the concept of absolute space and the concept of absolute time and the concept of the nature of matter were at war with each other. It was the genius of Einstein and his associates to see the nature of the conflict and to help remove it by clear and direct thinking. Reduced to its simplest terms, their argument is as follows: If absolute space conflicts with absolute time, why not think of them as relative? The second question is, relative to what, and the answer is relative to each other. Thus space-time replaced the concept of absolute time and absolute space. All measurements are made relative to the observer, and such measurements rest on the well-known postulate of the relativity of simultaneity.

But again it was realized that there is no guarantee that space-time is physical, and thus in the Special Theory of Relativity a new yardstick was selected to which space-time measurements could be referred. This new yardstick is the absolute velocity of light. Thus it seemed that at last science had discovered a physical referent for matter in motion. It will be recalled that Galileo had stated his principle of relativity positively by saying that the laws of physics retained the same form when transferred from one inertial system to another, or from one Galilean frame of reference to another. He stated it negatively by indicating that no mechanical experiment within an inertial frame of reference could determine whether that system was at rest or in uniform rectilinear motion. Thus an external referent for motion was needed to determine its direction and magnitude. When the full implications of this old principle were realized with respect to using the absolute velocity of light as a universal referent, another conflict appeared, because, assuming that the velocity of light is absolute, you are asserting that its speed may be internally determined. This conflict is another indication of the fact that absolutes cannot be picked willy-nilly and in contradiction to the facts of observation. It must be remembered, also, that nature exhibits no ideal straight lines and that, on the contrary, the motions of physical bodies follow curvilinear paths.

Now the curved path is the geometrical index of an accelerated body. Thus it follows that all physical bodies must move in a non-Galilean frame of reference. It is therefore evident that

the principle of relativity must be extended from Galilean to non-Galilean frames of reference.

This extension was accomplished in one of the most spectacular syntheses of this era. A re-examination of the work of Clerk Maxwell on optics, electricity, and magnetism led to the formulation of the Matter-Energy Tensor. The Matter-Energy Tensor made it possible to determine the Potential Distribution in any physical system. The great problem then became to discover an equivalent geometrical statement. Such a statement was derived from the work of Riemann and others. It was set equivalent to the Matter-Energy Tensor and an amended law of gravitation appeared. Thus it became possible, when Potential Distribution could be discovered, to determine the space-time surrounding any object; and finally a new and truer absolute was discovered, one vastly more consistent with the objects of physical science. This new absolute was the constitution of matter itself. At last it seemed that mathematical means of measurement had acquired a physical significance and were no longer a mere projection of the mind. Now it so happened that the geometric equivalent of the Matter-Energy Tensor described a four-dimensional space-time continuum and, miraculously, the fourth dimension turned out to be describable as a time dimension. Rest of physical bodies in a void became a purely arbitrary determinant, and dynamic equilibrium took its place. Thus the nature of the physical universe was revealed and the world of the mind was brought into conformity with the world of matter. A thorough-going physical theory of nature became possible.

An obvious extension of the results of these discoveries appeared in the form of Theories of the Finite Universe. These took various forms, such as Einstein's, DeSitter's, and Eddington's, depending on the points of view of their authors. If all matter travels in a non-Galilean frame of reference or a geodesic, its curved path demands that it cannot project itself infinitely, and if this is true, the universe must be finite; and it seems equally true that if space-time is conditioned by matter in motion, multiple fields or multiple space-time referents are demanded. And if we add to these two facts a third, that the smallest elements of matter are self-moving, the deduction which must be drawn is that this physical universe is a combination of order and disorder. The disorder stems from the self-moving character of the microscopic atoms. The order appears in relations between molar bodies as a fact of observation. This seemingly contra-

dictory fact is also reflected in the relation of quantum mechanics and Heisenberg's Principle of Indeterminacy to wave mechanics. Stated simply, the query is pertinent, "Why do we experience order at all?", and if we are to follow the general tenor of thinking here presented, we must seek a physical reason for a physical order. An answer has been given to this query by F. S. C. Northrop of Yale. The answer at first appears as somewhat bizarre and imaginatively inconceivable, but the concept of the electron is equally imaginatively inconceivable. Northrop's answer is called the Macroscopic-Atomic Theory. It rests fundamentally on four contentions:

1. A referent is needed for motion.
2. This referent must be physical.
3. Einstein gives only a mathematical meaning to the variable in his general law of gravitation which describes the boundary conditions of the finite universe. If such is to be rendered consistent with the general tenor of his thinking, this variable must have a physical meaning.
4. It is assumed that the theory of the spherical universe is satisfactory.

When the obvious implication from these four contentions is drawn, we get the following result: The universe is surrounded by a continuous spherical shell which is a single substance with an inner field. Unusual as this concept is, it answers some of the questions left open by wave mechanics and quantum mechanics. This entity is to be known as the Macroscopic Atom. In the first place, it offers a physical referent for motion; secondly, it is physical; third, it gives a physical meaning to Einstein's mathematical variable in his general law of gravitation; fourth, it gives a physical meaning to the concept of a spherical universe.

Thus if Northrop's hypothesis is plausible, this physical universe is composed of the macroscopic atom and its interior homogeneous field that accounts for the order which we experience. Imposed upon this general metrical uniformity, we have microscopic metrical heterogeneity and variability as functions of the self-moving microscopic particles and their multiple fields. And again we may say, not only practically but theoretically, that the physical universe is a combination of general macroscopic order and local microscopic disorder and variability. Matter is both atomic and continuous; space, being coincident with the

inner field of the macroscopic atom, is absolute and continuous, but also variable with respect to the fields of the microscopic atom; and time is a function of the motion of matter.

Such are some of the implications which may be drawn from the amazing progress of science within this century, and such is one hypothesis which avoids some of the problems of materialism and idealism.

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THE EFFECT OF THE PLEISTOCENE EPOCH ON THE GEOLOGY AND GROUND WATER OF SOUTHERN FLORIDA[1]

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INTRODUCTION

This paper dealing with effect of the Pleistocene epoch upon the geology and ground water of southern Florida is principally a result of studies made as part of the comprehensive investigation of water resources in southeastern Florida by the U. S. Geological Survey in cooperation with Miami, Miami Beach, Coral Gables, Dade County and the Florida Geological Survey. The area covered in this report includes that part of peninsular Florida which lies to the south of Sarasota, DeSoto, Highlands, Okeechobee, and St. Lucie Counties. The largest amount of research, however, has been done inside the Everglades Drainage District and especially in eastern Dade County.

Because of the need for geological and hydrological data to be used by the Soil Conservation Service in evaluating land capabilities, and in designing and locating structures for control of the water table, muck fires, and soil subsidence in the Everglades. the U. S. Geological Survey cooperated with the Soil Conservation Service in the drilling and pumping of 30 exploratory test wells most of which are located within the boundaries of the Everglades Drainage District. This exploratory test drilling was invaluable to the comprehensive investigation of water resources inasmuch as it furnished essential information concerning the geological formations and the quantity and quality of the ground water in the area inland from the Atlantic Coastal Ridge.

[1] Published with the permission of the Director, U. S. Geological Survey, Washington, D. C.

Editorial Note: This paper, although similar in content to that published earlier this year by Parker and Hoy in the *Proceedings of the Soil Science Society of Florida*, volume V-A (see citation on p. xx), summarizes the results of investigations which are of great interest and importance, and which deserve to be widely known. We are therefore making it an exception to our general policy against re-publication of material that has appeared elsewhere.

In addition to these 30 wells jointly installed with the Soil Conservation Service, the U. S. Geological Survey had previously drilled 48 exploratory test wells (Fig. 1) from which cuttings of the rock were examined and samples of the water analyzed. The study of the rock cuttings and fossils from these wells has not yet been completed.

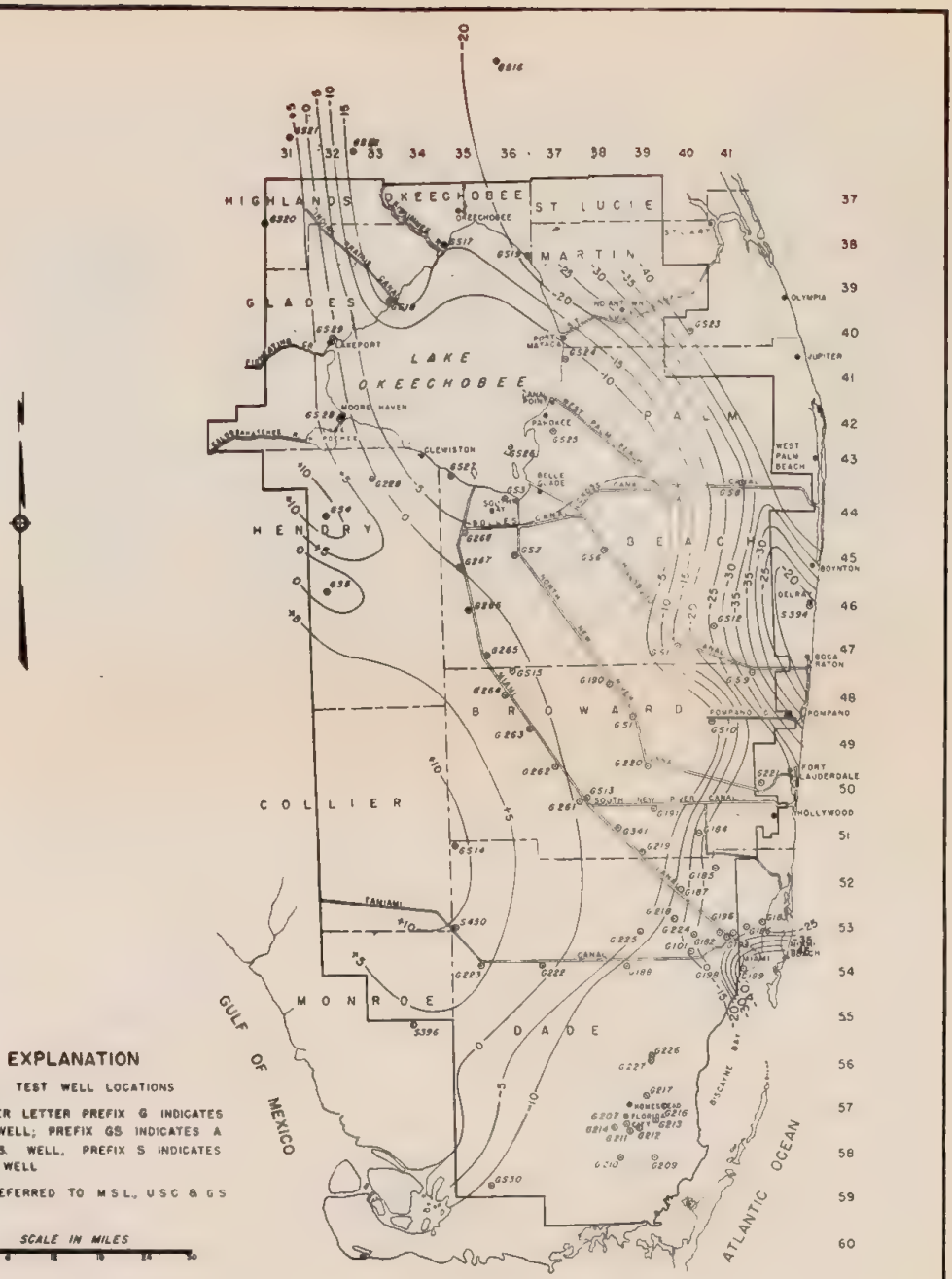
Acknowledgments

In acquiring and assembling the data for this paper the writer has become indebted to many persons, especially to colleagues in the U. S. Geological Survey and to cooperating officials. To O. E. Meinzer, geologist in charge of the Ground Water Division, under whose general supervision the ground water investigation in southeastern Florida was done, and to V. T. Stringfield, who directly supervised the project, much credit for any merit this work may have is due. C. Wythe Cooke has worked with the writer on the geology of this area and has been associated with him in developing many of the ideas here presented concerning the geologic history. Nevin D. Hoy and Russell H. Brown have been especially helpful in field, laboratory and office. Julia Gardner, Lloyd G. Henbest, Joseph A. Cushman, Horace G. Richards, Remington Kellogg, and W. Storrs Cole identified fossils; S. Kenneth Love supervised the analysis of water samples. Richard F. Flint, Robert B. Campbell and A. G. Unklesbay have aided with helpful ideas and criticism; each has critically reviewed the manuscript.

The author is greatly indebted to C. Kay Davis and John C. Stephens of the Soil Conservation Service, U. S. Department of Agriculture, who have aided effectively by arranging for and assisting with the drilling of the 30 jointly-installed exploratory test wells; by supplying equipment for transportation in and out of portions of the Everglades heretofore impenetrable; and by furnishing level data to remote parts of the Everglades.

Without the whole-hearted support and personal efforts of many interested people the investigation could not have succeeded. Among those whose help has been most important are the following: Herman Gunter, Director, Florida Geological Survey; Alexander Orr, former Mayor of Miami; W. A. Glass, Director, Department of Water and Sewers, City of Miami; Earle M. Rader,

Fig. 1, Map of the Everglades Drainage District showing location of exploratory wells and contours on the Pliocene surface.



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MAP OF THE EVERGLADES DRAINAGE DISTRICT SHOWING CONTOURS ON THE PLIOCENE SURFACE

Dade County Engineer; A. P. Black, consulting engineer, Gainesville, Florida; Malcolm Pirnie, consulting engineer, New York, N. Y.; A. B. Curry, City Manager, Miami; Claude A. Renshaw, City Manager, Miami Beach; George N. Shaw, City Manager, Coral Gables; and John B. Hurst of the Hurst Drilling and Equipment Company, Miami. Many others, too numerous to mention, have aided effectively. To all who have been of assistance or help in any manner whatsoever, the writer extends his grateful thanks.

Previous Reports

As a result of the comprehensive investigation of water resources in southeastern Florida the following papers have been written by members of the staff of the U. S. Geological Survey:

(1) Brown, Russell H. 1944. Water levels and artesian pressure in Florida, 1942. *U. S. Geol. Surv. Water-Supply Paper* 945: 10-48.

(2) Brown, Russell H., and Garald G. Parker. 1944. (Abstract): Salt water encroachment in limestone at Silver Bluff, Miami, Florida. *Economic Geology*, 39(1): 87. Jan.-Feb., 1944.

(3) Brown, Russell H., and Garald G. Parker. 1945. Salt water encroachment in limestone at Silver Bluff, Miami, Florida. *Economic Geology*, 40 (4): 235—262. June-July, 1945.

(4) Collins, W. D., C. S. Howard, and S. K. Love. 1943. Quality of the surface waters of the United States, 1941. *U. S. Geol. Surv. Water-Supply Paper* 942: 3, 9-26.

(5) Collins, W. D., and S. K. Love. 1944. Quality of the surface water of the United States, 1942. *U. S. Geol. Surv. Water-Supply Paper* 950: 2, 5-14.

(6) Cooper, H. H., and Garald G. Parker. [1944]. Water levels and artesian pressure in Florida, 1943. *U. S. Geol. Surv. Water-Supply Paper* 987 (in press).

(7) Cross, W. P., and H. H. Cooper. 1940. Water levels and artesian pressure in Florida, 1939. *U. S. Geol. Surv. Water-Supply Paper* 886: 64-69.

(8) Cross, W. P., S. Kenneth Love, Garald G. Parker, and D. S. Wallace, [1941]. Progress Report on water resources investigations in southeastern Florida. (Mimeographed manuscript in files of *U. S. Geol. Surv.;* text in vol. 1, accompanying illustrations in vol. 2).

(9) Cross, W. P. 1942. Water levels and artesian pressure in southeastern Florida, 1940. *U. S. Geol. Surv. Water-Supply Paper* 907: 26-34.

(10) Cross, W. P. and S. Kenneth Love. 1942. Ground water in southeastern Florida. *Jour. Am. Water Works Assn.*, 34(4): 490-504.

(11) Cross, W. P. 1943. Water levels and artesian pressure in southeastern Florida, 1941. *U. S. Geol. Surv. Water-Supply Paper* 907: 19-27.

(12) Ferguson, George E. 1943. Plan and progress of recent surface water studies in the Everglades. Proc. Soil Sci. Soc. Florida, IV-A, 1942 [1943]: 77-85.

(13) FERGUSON, GEORGE E. 1945. Summary of three years of surface water studies in the Everglades. Proc. Soil Sci. Soc. Florida, V-A, 1943 [1945]: 18-23.

(14) LOVE, S. KENNETH. [1945]. Cation exchange in ground water contaminated with sea water near Miami, Florida. *Trans. Am. Geophys. Union.*

(15) LOVE, S. KENNETH, AND H. A. SWENSON. 1942. Chemical character of public water supplies in southeastern Florida. *Jour. Am. Water Works Assn.*, 34(11): 1624-1628.

(16) PARKER, GARALD G. 1943. Notes on the geology and ground water of the Everglades in southern Florida. *Proc. Soil Sci. Soc. Florida*, IV-A, 1942 [1943]: 47-76.

(17) PARKER, GARALD G., 1945. Salt water encroachment in southern Florida. *Jour. Am. Water Works Assn.* 37 (6): 526-542. June, 1945.

(18) PARKER, GARALD G., AND N. D. HOY. 1945. Additional notes on the geology and ground water of the Everglades in southern Florida. *Proc. Soil Sci. Soc. Florida*, V-A, 1943 [1945]: 33-55, 77-94.

(19) PARKER, GARALD G., AND C. WYTHE COOKE. 1944. Late Cenozoic geology of southern Florida with a discussion of the ground water. *Florida Geol. Surv. Bulletin* 27: 119 pp., 4 figs., 26 pls.

(20) PARKER, GARALD G., GEORGE E. FERGUSON, AND S. KENNETH LOVE 1944. Interim report of water resources in southeastern Florida with special reference to the Miami area in Dade County, Florida. *Florida Geol. Surv. Report of Investigations*, No. 4: 39 pp., 9 pls.

(21-23) PARKER, G. L., AND OTHERS. Surface water supplies of the United States, South Atlantic slope and eastern Gulf of Mexico basins. *U. S. Geol. Surv. Water-Supply Papers* 892, 922, and 952. [These publications contain records of canal discharge in southeastern Florida for the years 1940, 1941, and 1942 respectively].

GEOLOGIC HISTORY

General Considerations.—The history of the earth is recorded in the rocks and can be read by those trained to read it. The story is not always easily deciphered, however, because in no place is a complete sequence of pages and chapters to be found. Indeed, some of the parts of this fascinating story are entirely missing, and the available ones are often widely scattered over the earth. The various chapters of this geological book are the rock units that are called formations (Fig. 2), and the pages are the individual members, or layers within the formations. The characters in which the records are written are manyfold; they may be the fossil remains of animals or plants that lived and died during the time of the deposition of the formation; they may be ripple marks in the sand or rain-drop marks in the ancient mud now turned to stone; they may be pebbles arranged in a fashion indicating that a long since vanished stream once

flowed in a certain direction there; they may be one thing or another, but all have their part in telling the story.

In southern Florida only relatively young rocks are penetrated in the drilling of the deepest water wells, and the oldest of these rocks does not antedate the uppermost Eocene, which was deposited possibly fifty million years ago. A few wells reach into the Miocene rocks, many into the Pliocene, and many others are developed in the Pleistocene.

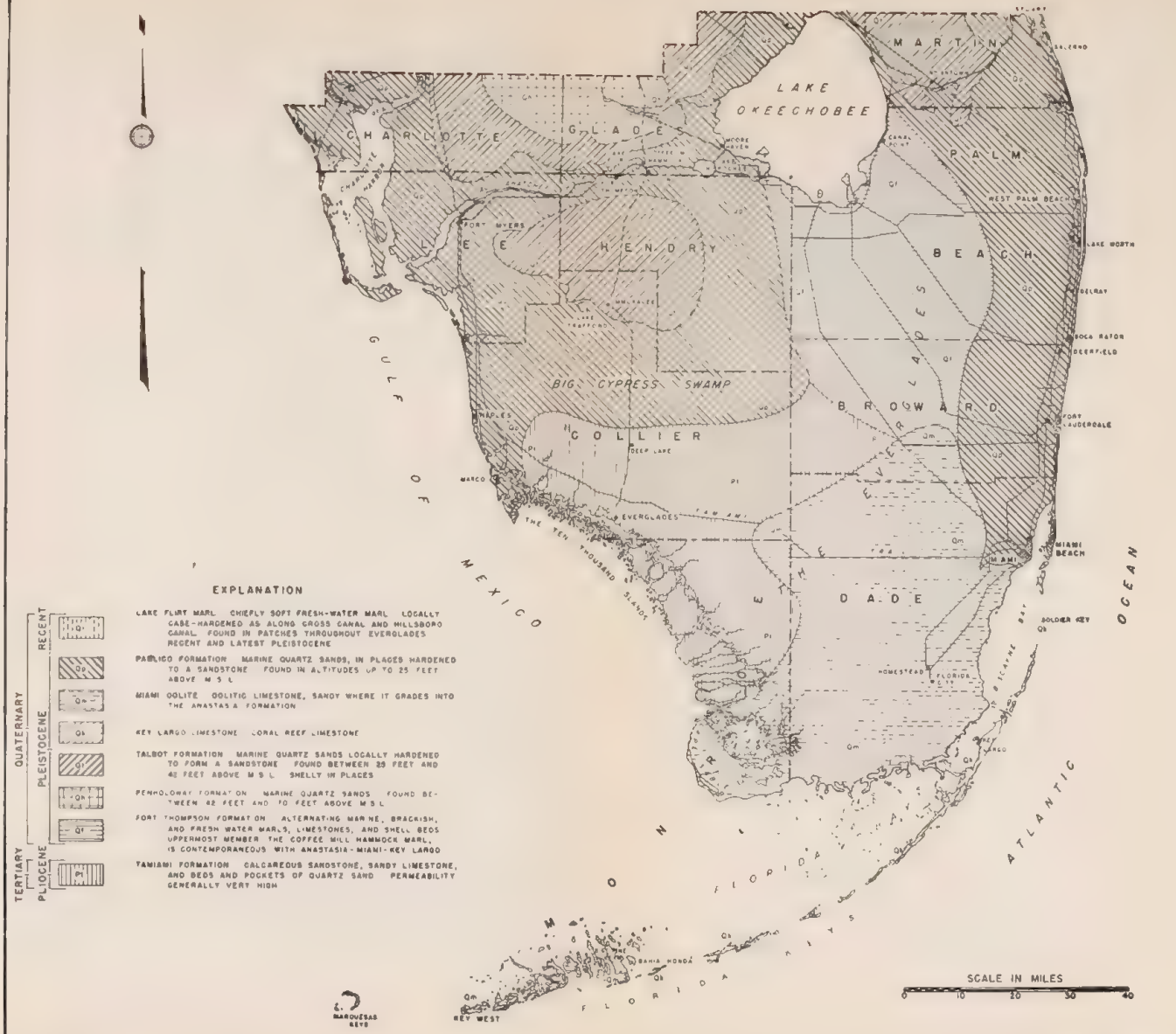
When one tries to date geological events in years he is almost attempting the impossible, so the geologist would rather divide time into great divisions and lesser ones, and still lesser ones, based principally upon the types of life existing then as shown by the fossil record preserved in the rocks. Thus geological time is divided into eras, periods, epochs, and ages;[2] only those few dates are listed which have been well established by dating from the best geological time clock, the slow, steady, apparently unchanging rate of disintegration of the radio-active minerals uranium and thorium. By this means it has been reckoned that the age of the earth is about 1,850 millions of years.[3]

Other (and less reliable) means have been devised to date geological events. Some of these are based on the amount of salt in the sea, the known rate of sedimentation in such basins as the Gulf of Mexico off the mouth of the Mississippi, or the Mediterranean off the mouth of the Nile, and the rate of filling of lake basins behind dams. Another method has been based on the recession of river falls, such as that of the Niagara, calculating an average rate of recession per year and dividing the length of the gorge by this rate, thus establishing approximately the date of the withdrawal of the great glaciers which allowed the river to come into being. Still another method has been that of counting the annual silt and clay layers (called varves by geologists) formed in glacial lakes, and thus estimating the amount of time since the great glaciers started their withdrawal. These varves are to a glacial lake much as annual growth rings are to a tree. From them the age of the lake can be determined, and much about the

[2] In this paper the terms "age" and "stage" appear frequently. These terms are not sysonymous; age is a time term, whereas stage is a stratigraphic term.

[3] Knopf, Adolph, and others. The age of the earth. *National Research* Council Bull. 80, 1931.

Fig. 2, Geologic map of southern Florida.


MARTIN
LAKE OKEECHOBEE
CHARLOTTE
GLADE
PALM BEACH
HENDRY
BROWARD
COLLIER
DADE
BIG CYPRESS SWAMP
EVERGLADES
GULF OF MEXICO
ATLANTIC OCEAN
FLORIDA KEYS
FORT MYERS
NAPLES
MARCO
EVERGLADES
MIAMI
MIAMI BEACH
HOMESTEAD
FLORIDA CITY
BISCAYNE BAY
SOLDIER KEY
WEST PALM BEACH
LAKE WORTH
DELRAY
BOCA RATON
DEERFIELD
FORT LAUDERDALE
KEY WEST
BAHIA HONDA
MARQUESAS KEYS
THE TEN THOUSAND ISLANDS
SCALE IN MILES
0 10 20 30 40
EXPLANATION
QUATERNARY
RECENT
PLEISTOCENE
TERTIARY
PLIOCENE
LAKE FLIRT MARL CHIEFLY SOFT FRESH-WATER MARL LOCALLY CASE-HARDENED AS ALONG GROSS CANAL AND HILLSBORO CANAL FOUND IN PATCHES THROUGHOUT EVERGLADES RECENT AND LATEST PLEISTOCENE
PAMLICO FORMATION MARINE QUARTZ SANDS, IN PLACES HARDENED TO A SANDSTONE FOUND IN ALTITUDES UP TO 25 FEET ABOVE M S L
MIAMI OOLITE OOLITIC LIMESTONE, SANDY WHERE IT GRADES INTO THE ANASTASIA FORMATION
KEY LARGO LIMESTONE CORAL REEF LIMESTONE
TALBOT FORMATION MARINE QUARTZ SANDS LOCALLY HARDENED TO FORM A SANDSTONE FOUND BETWEEN 25 FEET AND 42 FEET ABOVE M S L SHELLY IN PLACES
PENHOLOWAY FORMATION MARINE QUARTZ SANDS FOUND BETWEEN 42 FEET AND 70 FEET ABOVE M S L
FORT THOMPSON FORMATION ALTERNATING MARINE, BRACKISH, AND FRESH WATER MARLS, LIMESTONES, AND SHELL BEDS UPPERMOST MEMBER THE COFFEE MILL HAMMOCK MARL, IS CONTEMPORANEOUS WITH ANASTASIA-MIAMI-KEY LARGO
TAMIAMI FORMATION CALCAREOUS SANDSTONE, SANDY LIMESTONE, AND BEDS AND POCKETS OF QUARTZ SAND PERMEABILITY GENERALLY VERY HIGH

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climate during the period of their deposition can be told. Based on such methods, the following approximate dates have been derived for the epochs of the Cenozoic era[4]—the times during which the rock formations utilized for water supply in southern Florida were laid down.

Era	Period	Epoch	Duration in millions of years	Time since beginning of each epoch in millions of years
Cenozoic	Quaternary	Recent		
		Pleistocene	2	2
	Tertiary	Pliocene	15	17
		Miocene	20	37
		Oligocene	10	47
		Eocene	13	60

In the immense lengths of geological time many great mountain ranges have been lifted high above the sea, only to be eroded away, leaving few traces of their former existence. The oceanic basins change in volume due to warping of the earth's crust, and the seas invade the continents and may remain for some millions of years before withdrawing again under changed crustal conditions. Climates alter with the shifting of oceans upon or off the continents; or with the lowering of barriers, such as the Isthmus of Panama, which affect the movement of great ocean currents; or with the occurrence of clouds of sun spots that cut down radiation from the sun; or with changes in the constituents of the atmosphere, such as carbon dioxide and water vapor which have great capacity for storage of heat, and which, in sufficient amounts, may act as a thermal blanket for the earth.

[4] Hotchkiss, W. O. 1932. *The Story of a Billion Years.* (Williams & Wilkins Co., Baltimore). 137 pp., ill. (p. 55). Although Hotchkiss lists the Pleistocene as having had a duration of approximately two million years, many other geologists regard the length of that epoch as having been more nearly one million years. The evidence is not conclusive for either interpretation. For an evaluation of the methods used for dating events and determining duration during the Pleistocene see: Flint, Richard F. 1945. Chronology of the Pleistocene epoch. *Quart. Jour. Florida Acad. Sci.*, 8 (1) : 1-34, ill.

The Pleistocene or "Great Ice Age."—At the close of the Pliocene epoch a marked change took place in the earth's climate—a change that brought about the development of great systems of continental and alpine glaciers. The continental glacial sheets covered about one-third of the land area in the northern hemisphere and a somewhat smaller area in the southern hemisphere. The North America glacial sheets, including the Cordilleran complex, reached from Labrador to Alaska and pushed down from Canada until they covered that part of the northern United States that extends south to a line stretching, roughly, from Long Island, N. Y., through Cairo, Illinois, to the southern tip of Puget Sound in western Washington. The Scandanavian sheet extended across the Baltic Sea into the plains of northern Germany and western Russia, and covered all of Holland, Belgium, and most of the British Isles—an area about half as great as the glaciated region in North America. The extent of the glaciation in the southern hemisphere is not yet well known; at least it covered Patagonia and parts of Australia and New Zealand. In addition to the continental ice sheets, extensive and well-developed alpine glacial systems existed. Valley glaciers often extended far beyond the termini of modern glaciers, and even spread beyond the foothills to coalesce into piedmont glaciers, often of considerable extent.

The continental ice sheets were tremendously thick; in fact, the North American sheet is estimated to have been "at least 5,000 to 6,000 feet thick at the center of dispersal and it may have been as much as 10,000 feet. It has been found (Wegener, 1931) that the Greenland ice sheet reaches a thickness of 8,800 feet near its center in latitude 72° north, and averages over 4,500 feet thick over a large area."[5] The North American glacial sheets stripped a large part of Canada to bedrock, and deposited much of Canada's rock material as rich soil in north-central United States.

The Pleistocene, however, was not a time of continuous glaciation; rather, it was a time of alternate glaciation and de-glaciation as the climate repeatedly changed from cold to warm. The times of glaciation are called glacial ages, and the times of deglaciation are called interglacial ages. The last major change in climate that brought about withdrawal of the major continen-

[5]Schuchert, Charles and Carl O. Dunbar. 1933. *Geology, Part II, Historical Geology*, 3rd Edition (John Wiley & Sons, N. Y.). (p. 422).

tal ice sheets marks the beginning of the Recent epoch. However, as a matter of fact, it is probable that our Recent epoch should not be so ranked at all, but instead should be regarded as another of the interglacial ages of the Pleistocene. Certainly large masses of ice on a continental scale, such as the Greenland sheet and the Antarctic sheet, still exists. Lobeck[6] has reckoned the extent of these sheets as totalling approximately 6,000,000 square miles, and that enough water is stored in this ice to raise the sea level about 150 feet if it were released to the ocean. Although all geologists do not agree on this figure it is generally conceded that the amount is significant. Longwell, Knopf, and Flint[7] conservatively estimate that "the complete wastage of the polar ice sheets existing today would return enough water to the sea to raise its level about 80 feet. . . ."

The causes for the waxing and waning of the great ice sheets are not definitely known. Possibly they are due to a combination of the factors previously enumerated, but the fact of the existence of the several great glacial sheets cannot be doubted. Their distribution of rocks foreign to the regions where they are now found, their terminal and ground moraines, their gouging of deep lake basins, their rearrangement of stream patterns, and many other evidences are excellent proof of their existence. Furthermore, their effect on the life of man today through control of topography, soil types, ground water, surface water, and certain mineral deposits, is of utmost importance. It is worthy of note that their influence extended far beyond the confines of the glacial sheets themselves; even tropical areas of the world were influenced, principally as a result of glacial control of sea level. Daly[8] has pointed out that the occurrence of many coral reefs may thus be accounted for.

General Effect of Glacial Control of Sea Level

The sea level fell during times of glaciation because of the huge draft on the ocean waters needed to produce the massive continental glaciers; it rose again as the glaciers retreated

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[6] Lobeck, A. K. 1939. *Geomorphology.* (McGraw-Hill Book Co., N. Y.). (p. 299).

[7] Longwell, Chester R., Adolph Knopf, and Richard Flint. 1932. *Textbook of Geology, Part I, Physical Geology.* (John Wiley & Sons, N. Y.). (p. 153).

[8] Daly, R. A. 1934. *The changing world of the ice age.* (Yale Univ. Press, New Haven). 271 p.

during the warm interglacial ages. This fall and rise occurred several times with world-wide effects. With each succeeding glacial age the ice front in North America did not advance as far to the south as it had previously; also, with each succeeding interglacial age the high-water mark of the ocean was lower. Whether the difference of ocean level in each succeeding interglacial age is due to successive enlargements in the capacity of the oceanic basins brought about by crustal movements in some distant part of the earth, or to more and more ice remaining locked on land during each subsequent interglacial age, or both, is not known. However, the changing ocean levels resulted in the formation of shorelines with their characteristic features wherever the ocean halted long enough for their development.

Where these ancient shore lines are now beneath the ocean they can seldom be seen, and are therefore very difficult to recognize; in some instances, however (Cooke,[9] Stearns and Macdonald,[10] Veatch and Smith,[11]) they have been detected and mapped. Where the shore lines lie above present ocean level they often may be located by those familiar with shore lines and shore line processes despite subsequent modification by weathering, erosion, and solution. Eight such shore lines have been described along the Atlantic seaboard alone (Cooke,[12] Parker and Cooke[13]); and in Hawaii and the south Pacific, Stearns[14] has detected four corresponding ones and six others that are not apparent in the southeastern United States. In Cuba, Meinzer[15] has noted and described the occurrence of seven Pleistocene marine terraces of which the one whose shore line is about 40 feet above present sea level is "most persistent and best preserved throughout the region." Meinzer notes that "the terraces consist largely of benches cut into the older rocks, and are mantled with soft, massive coral limestone."

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[9] Cooke, C. Wythe. 1939. Scenery of Florida. *Florida Geol. Surv. Bull.* 17: 33-58.

[10] Stearns, Harold T., and G. A. Macdonald, 1942. Geology and ground water resources of the island of Maui, Hawaii. *Terr. of Hawaii, Div. of Hydrography, Bull.* 7: 54-55, 153-154.

[11] Veatch, A. C., and P. A. Smith. 1939. Atlantic submarine valleys of the United States. . . . *Geol. Soc. Am., Special Paper* No. 7: 101 pp., ill.

[12] Cooke, C. Wythe. 1931. Seven coastal terraces in the southeastern states. *Jour. Wash. Acad. Sci.*, 21: 503-515.

[13] Parker and Cooke, *op. cit.* [see p. xx, ref. 19], pp. 20-27.

[14] Stearns, H. T., *op. cit.* [see footnote 10]. p. 54.

[15] Meinzer, O. E. 1933. Guantanamo Bay reconnaissance. *Jour. Wash. Acad. Sci.*, 23(5): 256-258.

TABLE I—TENTATIVE CORRELATION OF FORMATIONS IN SOUTHERN FLORIDA

Epoch	*Age*		*Shore line altitude above* MSL	*Upper Caloosahatchee River Valley Area*		*Central Everglades Area*	*Southeastern Coastal Area*
RECENT			0	Solution and erosion. Sand bars, dunes, and old channel fills. Deposition of Lake Flirt marl and organic soils of Everglades.		Organic soils of Everglades. Lake Flirt marl.	Solution and erosion. Formation of beach ridges, organic soils and marl beds (Lake Flirt marl). Local dunes.
PLEISTOCENE	Wisconsin		−25	Solution and erosion. Basal Lake Flirt marl.		Solution and erosion. River cuts and fills. Basal Lake Flirt marl.	Solution and erosion. Basal Lake Flirt marl.
			5 25	Pamlico sand.		*Rangia cuneata* beds.	Pamlico sand.
		"Iowan" sub-age	−?	Solution and erosion. Black carbonaceous sands.		Solution and erosion.	Solution and erosion; especially deep cuts in Miami oolite.
	Sangamon interglacial		42 70 100	Fort Thompson formation	Coffee Mill Hammock marl member (marine shell bed).	Undifferentiated.	Miami oolite and upper parts of Anastasia formation. Key Largo limestone.
	Illinoian glacial		−?		Highest fresh water limestone ledge, merging into soft fresh-water marl below.	Hard fresh water limestone.	Solution and erosion.
	Yarmouth interglacial		170 215		Marine shell marl, "*Pecten* horizon."	Undifferentiated.	Undifferentiated, possibly middle and lower parts of the Anastasia formation and Key Largo limestone.
	Kansan glacial		−?		Lowest fresh water marl, locally indurated making a shelf.	Solution and erosion.	Solution and erosion.
	Aftonian interglacial		270		Marine shells (local; often mixed with basal part of overlying fresh water shells).	Undifferentiated.	Undifferentiated. Basal Anastasia formation. Basal Key Largo limestone(?).
	Nebraskan glacial		−?	solution and erosion			
PLIOCENE				Caloosahatchee formation.		Caloosahatchee formation. Tamiami formation.	Tamiami formation.

As long ago as 1913 Matson[16] described and named three marine terraces in Florida with shore lines at elevations of approximately 100, 70, and 40 feet above present day sea level. In the lowest of these terraces, which he called the Pensacola, Matson recognized a second division with a shore line at about 20 feet. He did not have adequate field data, however, to map this lowest shore line, so did little more than mention it. Many other geologists likewise have noted the occurrence of terraces in Florida, and a controversy developed over whether or not their shore lines reflect westward tilting of the Florida peninsula (Leverett[17]). Cooke, who has given much time to the study of the Pleistocene shore lines and their associated sea floors (the terraces) along the Atlantic coast, has traced the eroded remnants of the shore lines from New Jersey southward into Florida, has checked their elevations, and finds that they are approximately level. He, therefore, arrives at the conclusion that no great movements of land with respect to sea level have taken place in this area since the close of the Pliocene. In addition, work of the writer on the younger Pleistocene shore lines in Florida south of Orange county has indicated that they are approximately horizontal, and if any late Pleistocene tilting of the Floridian Plateau is involved it is of a very minor amount.

Effect of Changing Sea Levels in Southern Florida

Geologists have established by their work in the glaciated parts of North America that there were at least four major glacial stages separated by three major interglacial stages, and possibly five major glacial stages separated by four major interglacial stages.[18] The writer adopts the former view and lists them in Table I. In this interpretation the Iowan is regarded as a substage of the Wisconsin glacial stage.

The following correlation of deposits in southern Florida with these glacial and interglacial stages is tentative and is to be regarded as a working hypothesis only. In part it is based upon the work of Cooke,[19] who has previously assigned tentative ages to

[16] Matson, G. C. 1913. Geology and ground water of Florida; northern and central Florida. *U. S. Geol. Survey Water-Supply Paper* 319: 31-35.

[17] Leverett, Frank. 1931. The Pensacola terrace and associated beaches and bars in Florida. *Florida Geol. Surv. Bull.* 7: 1-44, map.

[18] Flint, Richard F. 1941. Glacial Geology, in: Geology, 1888-1938, *50th Anniv. Vol., Geol. Soc. Am.*, (1941): 22-25.

[19] Cooke, C. Wythe. 1935. Tentative ages of Pleistocene shore lines. *Jour. Wash. Acad. Sci.*, 25: 331-333.

the Pleistocene shore lines in southeastern United States as follows:

Terrace	Altitude of shore line (approximate)	Age (tentative)
Brandywine	270	Aftonian interglacial
Coharie	215	Yarmouth interglacial
Sunderland	170	
Wicomico	100	Sangamon interglacial
Penholoway	70	
Talbot	42	
Pamlico	25	Wisconsin sub-interglacial

The writer offers no suggestions for amending or changing Cooke's age-assignment, inasmuch as the topography of southern Florida offers no opportunity to work on terraces having shore lines higher than 100 feet; the lower shore lines and deposits appear to fit into this chronology. If the higher shore lines outside southern Florida are actually the product of Pleistocene marine environments much of the earlier Pleistocene shore line record is missing here; therefore, a sequence based on a complete set of Pleistocene shore lines cannot be made from evidence in southern Florida.

However at Fort Thompson on the Caloosahatchee River, one and three-quarters miles east of LaBelle, there is a sequence of Pleistocene deposits that records the effects of a fluctuating sea level in that area, and it is on this occurrence and the tracing of related marine beds elsewhere in southern Florida that much of the correlation is based.

The Caloosahatchee River section includes four Pleistocene marine beds (three in the Fort Thompson formation and one in the Pamlico) separated from one another by erosional unconformities and fresh water deposits.[20] If each of these marine beds represents an interglacial stage and the erosional unconformities and fresh water deposits represent glacial stages, then the sequence of major ocean level changes postulated as a result of the several glaciations and deglaciations during the Pleistocene is accounted for. However, there is nothing about these deposits to indicate the height of the ocean at its maximum altitude when

[20] Parker and Cooke, *op. cit.* [see p. xx, ref. 19], pp. 72-74, 89.

the deposits were being formed. As a matter of fact, these marine beds may well have been laid down when the ocean level was comparatively low, either during advancing or retreating phases in the slow fluctuation of the ocean level. Therefore, the Fort Thompson beds throw no light on the problem of the altitude of the shore lines of the higher terraces of the southeastern United States. Neither do the other low-lying Pleistocene marine deposits aid in solving the problem of the altitude of the higher shore lines. Their stratigraphic relationships have been the bases for assigning them to the several interglacial ages listed below.

Nebraskan glacial age.—When the sea withdrew at the beginning of Nebraskan time, a relatively flat area existed under the central part of the present Everglades. Higher land lay to the west in the present area of the Devil's Garden and the Big Cypress Swamp, and to the north about in the latitude of Tampa Bay. The deposits of the Pliocene sea were shelly, sandy and silty in these northern parts, and were limy and sandy in the lower Everglades area and along the southeast Florida coast. The Pliocene surface, from the flat area in the Everglades, apparently sloped rather steeply to the east under the present Atlantic Coastal Ridge. (See Fig. 1, which is based on exploratory test wells).

This Pliocene surface became exposed to weathering, and to the attacks of running surface water and percolating ground water. The latter was an especially potent factor because it created a network of solution holes in the calcareous rocks—especially in the Tamiami formation, the sandy limestone of Pliocene age in the southern part of the area—and started the action which, repeated in subsequent glacial ages, has made this rock unit one of the most productive aquifers that the U. S. Geological Survey has ever investigated. The Caloosahatchee formation and Buckingham marl, however, were not so affected; composed principally of sand and shells, with beds of silt, clay, and marl, they were not deeply eroded, though the surface doubtless was dissected locally by streams, especially by those flowing west into the Gulf of Mexico as consequent streams on the newly tilted Pliocene land surface. Ancestral Lake Okeechobee made its first appearance at this time, and in all probability many small lakes existed in the lower parts of the flat area to the south.

Aftonian interglacial age.—After the close of Nebraskan time, a warm period called the Aftonian interglacial age ensued, during which the great continental glaciers retreated, and the sea level may have risen to about 270 feet above its present level, forming the Brandywine terrace and associated deposits.[21]

If the Aftonian sea left sediments in south Florida they are very rare or are not recognized as such. Only a few scattered local patches of marine shells, generally found in depressions in the underlying Caloosahatchee formation and often mixed with the basal part of the overlying bed of fresh water marl, may be seen at Fort Thompson. Elsewhere in south Florida deposits of the Aftonian stage possibly are included in the undifferentiated Pleistocene series. These deposits, especially in the Fort Thompson area, were probably once much thicker than they now are, but have been thinned and in most places entirely removed by erosion and solution. The fact that the ocean was probably fairly deep here at its maximum during this age, and sources of detritus far distant, may be another factor in the problem.

This invasion of south Florida by the sea during the Aftonian interglacial age may have helped to distribute sand southward along the Atlantic coast, thus building up the early Pleistocene deposits (basal Anastasia formation) under the present area of the Coastal Ridge. Possibly, also, the basal portions of the Key Largo limestone were being formed by coral growth as a reef at or near the site of the present Florida Keys. The ocean water displaced the fresh ground water in the Pliocene formations, and probably washed enough sand into many of the solution holes, developed during Nebraskan time, to partially or completely fill them.

Kansan glacial age.—The cold Kansan glacial age succeeded the warm Aftonian interval and again the sea fell below its present level. Once more southern Florida became a wide land area with rivers, lakes, trees, grass, and strange animals [22] present. The sand which had been washed southward around the old flat area during the Aftonian time formed a low barrier and allowed a large, shallow, fresh water marsh and lake to exist in the present Everglades and upper Caloosahatchee River valley. In this marsh fresh water marl accumulated.

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[21] Cooke, C. Wythe, *op. cit.* [see footnote 9], pp. 33-35.

[22] Simpson, George G. 1929. Extinct land mammals of Florida. *Fla. Geol. Surv., 20th Ann. Rept.;* 229-279.

Once again fresh percolating ground water was at work flushing out the salt water, and it likely was very effective in the more permeable Tamiami formation. The Caloosahatchee formation may also have been flushed of its salt water, but owing to its lower permeability and the very slow rate of ground water movement through it this may not have been entirely accomplished.

Yarmouth interglacial age.—The Kansan glacial age was succeeded by the warm Yarmouth interglacial age. Cooke[23] has postulated that during this time the sea level may have risen to 215 feet above present sea level, stood there long enough to establish a definite shore line, and then fell to 170 feet, where it remained until the end of the age. Although none of these higher (270, 215, and 170 foot) shore lines or terraces are present in south Florida Cooke describes them as occurring along the Atlantic coast from central Florida northward to New Jersey.

In the Fort Thompson area the sea laid down a shell marl containing the shells of many scallops (*Pecten* sp.), marine swimming pelecypods. Doubtless this deposit was once much thicker than it now is, but like earlier deposits, it was largely removed by subsequent erosion. In other areas of southeastern Florida the coral reef (Key Largo limestone) once more was being built upon, and sand, a principal component of the Anastasia formation, continued to work southward, building up the east coast ridge, and enclosing enough of the present Lake Okeechobee-Everglades depression to allow a large, shallow lake and marsh to exist there in the succeeding interglacial age. This invasion by the sea once again filled the rocks with salt water and displaced the fresh water of the preceding age.

Illinoian glacial age.—As the climate cooled again, and the Illinoian glaciers spread far to the south of the dispersal centers, the ocean once more withdrew from the land and fell below present sea level. Land conditions again existed in southern Florida, and once more a wide, shallow lake and marsh existed in the Lake Okeechobee-Everglades depression. A wide-spread fresh water limestone and marl deposit was laid down which today is the most easily recognized member of the Fort Thompson formation. Solution and erosion took place on the higher land, and rivers wended their way from this shallow interior lake to the

[23] Cooke, C. Wythe, *op. cit.* [see footnote 19], pp. 331-333.

ocean. Once more fresh ground water began displacing the salt water; it dissolved the more soluble limy rocks and added to the already existing solution holes, thus making the Tamiami formation still more permeable.

Sangamon interglacial age.—With the melting of the Illinoian ice the ocean slowly rose during the Sangamon interglacial age. Cooke[24] postulates that it reached an elevation of 100 feet above present sea level, then fell to 70 feet, and finally to 42 feet by the end of the age. In each instance it remained long enough to produce marine terraces with well-preserved shore lines at those elevations. In southern Florida these shore lines are most readily apparent from the air and show plainly on airplane photographs. They are generally difficult to see on the ground, but some features along these old shore lines are so little changed by erosion as to be unmistakable when viewed even at close range. Best preserved of the three shore lines are the 42 and 70 foot ones, and least well preserved is the 100 foot one, the oldest. This is to be expected, for weathering has had more time to efface the features of the older ones.

At the beginning of the Sangamon, and again near its close when sea level may have ranged between about —20 and +20 feet with reference to present mean sea level, a bar of oolite (Miami oolite) was being built up along the eastern shore to the south of Boca Raton; north of this place the bar was sandy and shelly, and deposits of coquina, sand, and sandy limestone (the upper part of the Anastasia formation) were laid down (Fig. 2). Outside this bar, southward from the latitude of Miami, the coral reef that makes up the present Upper Keys was once again growing (Key Largo limestone), and behind this bar and reef, in the Lake Okeechobee-Everglades depression, myriads of marine and brackish water shells were accumulating which today make up the upper most member of the Fort Thompson formation (the Coffee Mill Hammock marl). Salt water again gained access to the rocks, displaced the fresh water, and sand worked into the solution holes.

On the higher terraces referred to the Sangamon interglacial age, especially on those that surround and underlie the Kissimmee River basin, the development of sand bars, beach ridges, and dunes took place. These features today dictate land usage through control over drainage, ground water, vegetation, and

[24] Cooke, C. Wythe, *op. cit.* [see footnote 19], pp. 331-333.

soil types. When the sea withdrew at the close of this interval it left many original depressions which today contain such consequent lakes as Istokpoga, Kissimmee, and the Tohopekaligas. The Kissimmee River is a consequent stream making use of the abandoned late Sangamon sea bottom north of Lake Okeechobee, which, itself, occupies an original depression in the Pliocene sea bottom that has been only slightly modified.

The deposits formed during Sangamon time gave southern Florida its modern appearance by building up the higher lands north, west, and east of the Lake Okeechobee-Everglades depression, and by the construction of the major part of the Coastal Ridge along the Atlantic shore.

Wisconsin glacial age and sub-ages.—Following Sangamon time the Wisconsin glacial age occurred, consisting of early (Iowan) and late Wisconsin glacial sub-ages, and an intermediate interglacial sub-age. The results, though much more complicated than here outlined, were about as follows: In the Iowan, or first glacial sub-age, the sea fell below its present level and solution and erosion were common on the higher land. From the lakes that existed in the interior cuts were made through low areas and abandoned tidal channels in the newly formed Atlantic Coastal Ridge, especially through the soft oolite between Miami and Fort Lauderdale. Dune building was common along the sandier shore areas, especially in St. Lucie, Martin, Palm Beach, and Collier Counties. Fresh water began to flush out the salt water left from the Sangamon invasion, but the time was short, and it may not have progressed very far, especially in the rocks of low permeability inland from the shore where flat water table gradients probably existed.

Then during the mid-Wisconsin interglacial sub-age there followed a time of warm weather; the ocean rose to 25 feet above present sea level, and remained long enough to produce the Pamlico terrace and formation (Pamlico sand) which, in southern Florida, is mainly quartz sand locally hardened into sandstone. This is the sand which mantles the Atlantic Coastal Ridge as far south as Coral Gables, often completely filling the channels cut through the oolite during the previous glacial sub-age. West of the Everglades this sand mantles the Pliocene higher land that underlies the Big Cypress-Devil's Garden area (up to altitude 25 feet above mean sea level and higher where it was heaped up into beach ridge and dune deposits), and to the north it sur-

rounds the higher terraces and generally encloses Lake Okeechobee except on the south and southeastern sides where the wide expanse of the Everglades meets the lake shore. Only a minor amount of the Pamlico sand found its way out into the present basin of the Everglades proper because the longshore currents that carried it south were not effective in the quieter water of this great shoal area. Again salt water displaced the fresh ground water, and sand worked its way down into solution holes.

Remnants of this Pleistocene salt water are still left in isolated patches in southern Florida, some of which have considerable areal extent, especially in the northern Everglades and around the southeastern side of Lake Okeechobee.[25] This mid-Wisconsin invasion by the sea is probably largely responsible for salt water found in other places on the Pamlico terrace in Florida, notably near Titusville in Brevard County. Although these ancient bodies of trapped sea water are often quite salty the waters do not now have the characteristics of modern sea water. This is probably due to modification by dilution with fresh water and by chemical reactions, mainly of the base-exchange variety, with organic soils and enclosing calcareous rocks.[26]

As this warm inter-glacial sub-age waned and the northern glaciers made a relatively short advance, the ocean level began to fall again, but not continuously. It halted long enough at 5 feet above present mean sea level to develop at Silver Bluff, in Miami, Florida, a low wave-cut sea cliff in the Miami oolite.[27] The cliff (Fig. 3) is undercut with a notch whose center is at 8 feet above sea level, and is bordered by a channeled wave-cut bench that gently slopes out below the present bottom of Biscayne Bay. This old 5 foot shore line, named the Miami, is readily traceable both northward and southward from Miami to and beyond Fort Lauderdale and Florida City respectively, but the cliff is seen best at Silver Bluff. North of Fort Lauderdale the materials are generally too sandy to preserve this shore line, and south of Florida City the land is too low.

After standing at 5 feet long enough to develop the Miami shore line, so excellently preserved at Silver Bluff, the ocean

[25]Parker, Ferguson, and Love, *op. cit.* [see p. 123, ref. 20], pp. 13-16.
[26]Love, S. Kenneth, *op. cit.* [see p. 123, ref. 14].

Figure 3. Silver Bluff, Miami, Florida, a low sea cliff cut in the Miami oolite when the ocean stood 5 feet above present mean sea level, near the close of Pamlico time. Note wave-cut bench sloping gently from the base of the cliff and wave-cut notch in the cliff face.

Fig. 3. Siver Bluff, Miami, Florida.

again continued its fall with the re-advance of the northern glaciers, and receded to 25[27] feet below present level.

The mid-Wisconsin (Pamlico) stand of the sea over southern Florida was the last one, and its marks are very evident today. The old bars and current-marked sand deposits are still noticeable, and are being only partially obliterated by surficial drainage, and then mainly in the vicinity of larger streams where a dendritic drainage pattern is being imposed on the parallel pattern of old beach ridges, off-shore bars, and intervening lagoons that marks some areas in the sandy flat lands in southern Florida, especially in St. Lucie, Palm Beach, and Martin Counties.

This parallel pattern is most notable from the air, and shows very plainly on the aerial photographs made for the Soil Conservation Service in 1940. The trend of the bars and swales parallels the present Atlantic shore line and is entirely confined to the sand land, and does not affect the surficial drainage in the organic soils of the Everglades where, from aerial photographs, one may see a similar arrangement of the drainage pattern. This latter pattern is entirely confined to the peat and muck soils, and has no relationship to the underlying floor of the Everglades.

With the fall of the sea level to about 25 feet below its present stand fresh water again became dominant over salt water in southern Florida. Once more a large shallow lake existed in the Everglades, and it may have been at this time that the lower portions of the Lake Flirt marl were deposited. Solution of the calcareous rocks and erosion of channels through the Atlantic Coastal Ridge became active once again, and quite likely the re-excavation of former channels that had been choked with Pamlico sand was furthered. Fresh ground water started displacing the new salt water body, left especially in the Lake Okeechobee-Everglades depression, and may have rather effectively cleared the Tamiami formation of its salt water.

During this last time of lowered sea level it is likely that growth of the sand dunes along the Atlantic and Gulf coasts continued and the dunes generally attained their present size and configuration.

Recent.—The beginning of Recent time was marked by the start of the final withdrawal of Wisconsin ice that was brought about by our modern climate. The melting back of the great polar ice sheets partially refilled the ocean basin, and sea level

[27] Cooke, C. Wythe. 1937. The Pleistocene Horry clay and Pamlico formation near Myrtle Beach, S. C. *Jour. Wash. Acad. Sci.*, 27(1) : 5.

gradually rose to its modern level; it drowned the mouths and channels of the short Florida east coast rivers and made estuaries of the larger ones, of which the St. Lucie is a good example. The rivers on the west coast are longer and larger, with wider and deeper valleys, so that when their lower courses were flooded they made larger estuaries and better harbors than did those of the east coast. Charlotte Harbor, the drowned mouth of Peace Creek and Miakka River, are good examples of the west coast estuaries.

Along with this rise in sea level came a slowing down of drainage from the interior and a rise in water table. Sand was transported southward along the shore, and the present beaches with their associated bars, islands, and spits took form. In many places shifting sand partially filled and choked the old tidal channels through the Coastal Ridge, which, at least partially, had been re-excavated by late-Wisconsin streams. Occasional hurricanes accompanied by huge storm waves and exceedingly high flood tides, redistributed the sand along the shore line and helped choke the old drainage ways from the Lake Okeechobee-Everglades depression.

The result of this blocking of drainage and rise of the water table was the development in the Everglades basis of the extensive marl, peat and muck soils. A great shallow marsh and lake area came into existence, probably extending from near LaBelle on the west to the Atlantic Coastal Ridge on the east, and from Okeechobee City on the north to the Tamiami Trail on the south. It was very swampy and shallow in the southern part, but was deeper to the north (20+ feet) where the present greatest depths of this basin are about at sea level. Its principal drainage outlets were through the Atlantic Coastal Ridge between Miami and Fort Lauderdale. The first deposits in this basin appear to have been the widespread Lake Flirt marl, a soft, sticky, white to gray calcareous mud, rich with the remains of certain freshwater mollusks such as the genera *Ameria* and *Planorbis*. As indicated by field studies, this marl was mainly deposited when the shallow waters evaporated seasonally, and the minerals dissolved in the water, principally calcium carbonate, were precipitated. This seasonal disappearance of the shallow water brought about the death of myriads of snails whose shells, upon disintegrating, added considerably to the total amount of calcium carbonate. Undoubtedly the activity of certain algae and plants brought about a large amount of the deposition. At any

rate, the marl is widespread in the Everglades, reaching a maximum thickness of 5 or 6 feet in the old Lake Flirt basin.

In the deeper parts of the area, where the water surface always remained above ground, plant remains accumulated until finally the peat and muck deposits of today were developed. As these materials accumulated and the basin became more and more nearly filled, the water level rose enough so that some of the higher of the old tidal channels across the Coastal Ridge came into use as discharge channels and modern natural drainage was affected. Short streams such as the Miami River, Arch Creek, New River, and many others came to have their modern form. Thus the surface waters in the Everglades, slowly moving more or less as a sheet in high water times, and very, very slowly in shallow channels in low water times, came to flow toward these outlets. As they moved, the waters imposed on the soft organic soils and flotant masses a linearly arranged drainage pattern. Trees chose the higher of the areas between the "swales," and the "bays" or "tree-islands" began to take form. Sawgrass or more aquatic plants chose the swales, and the result is the pattern which, as Dickerson[28] says, "reveals a decided 'grain' to a broad sweep of country . . . as if a great coarse broom had been rudely brushed over the low-lying Everglades region." Dickerson postulated ocean currents as the reason for this drainage pattern, but he interpreted the pattern from the aerial photographs and had not made actual studies of the phenomenon in the field.

Summary

As a result of widespread crustal movements, southern Florida emerged from the sea late in Pliocene time, and probably was slightly tilted to the west. At the beginning of the Pleistocene, the continent emerged still farther as a result of the lowering of sea level attending the first widespread glaciation. During this epoch southern Florida may have stood several hundred feet above sea level.

During the interglacial ages the sea repeatedly flooded southern Florida. The marine members of the Fort Thompson formation, in the Lake Okeechobee-Everglades depression and the Caloosahatchee River Valley, apparently are the deposits of these interglacial invasions by the sea. The fresh-water marls, sands,

[28] Dickerson, R. E. 1942. Trend of Pleistocene ocean currents across the Florida Everglades. *Geol. Rev.*, 32(1) : 136-139.

and organic deposits of the Fort Thompson formation appear to have accumulated during the glacial ages, while sea level was low and the area was occupied by fresh-water lakes and marshes. Elsewhere in southern Florida the deposits are mainly marine limestones and sandy terrace deposits.

The Pliocene surface upon which these Pleistocene sediments were deposited was highest to the north and west of the present Everglades and Kissimmee River basin and sloped gently to the south, southeast, and east. On this slightly sloping floor, alternately submerged and emerged, the later materials were built up which, modified by wind, rain, surface and ground waters, have determined the present topographic and ecologic aspects of southern Florida.

Of all the rocks of southern Florida the most important aquifer is the Tamiami formation, in which most of the wells are developed. Other formations carry less water and their yields are lower. The Pamlico sand, Anastasia formation, and Miami oolite are utilized in the development of small or shallow supplies. The Buckingham marl and the Caloosahatchee and Fort Thompson formations are generally of very low permeability. In the northern Everglades their less permeable parts contain highly mineralized waters, which appear to have been trapped in them since the invasions by the Pleistocene seas. These waters since have been modified by dilution with fresh ground water and by chemical reactions, mainly of the base-exchange variety with surrounding materials.

SIGNPOSTS IN HUMAN NUTRITION

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In reviewing the recent literature on human nutrition,[1] one finds clear indications of the trends that research and application relative to the diet of normal people will follow after the war. Some of these indications are as follows: (1) the growing significance attached to nutrition as a public health factor; (2) the emphasis on differentiating research in human nutrition from research based on laboratory animals; (3) the increasing amount of study being given to normal human physiological utilization of food nutrients; (4) the expressed need for and intensified research on better tests for diagnosing subclinical states of undernutrition; (5) greater emphasis on the analysis of foods and fluids as actually consumed in everyday life; and (6) recognition of the fact that so-called laboratory standards of accuracy, as applied to human nutrition, are in reality false and misleading.

The Growing Significance of Nutrition in Public Health

It is no secret that the draft revealed shocking figures on malnutrition among young American men. As a result of these findings, and of nutrition studies begun during the first world war, the army has added dietitians to its regular staff of officers. The federal government, states, and counties are employing nutritionists and dietitians in increasing numbers in the promotion of better public health, and have appointed nutrition committees to deal with the problem at these various levels. The National Research Council has set up tentative standards for nutrients commonly deficient in the American diet. The American Nutrition Foundation has been organized, is publishing the excellent new *Nutrition Reviews,* and is actively furthering research on many problems of human nutrition.

[1] This estimate of the recent trends in research on human nutrition has been based on examination of 267 articles and abstracts which appeared during 1943 and the first ten months of 1944 in *Nutrition Reviews, Journal of the American Dietetic Association, Journal of Nutrition,* and *Journal of the American Home Economics Association.* Reference was also made to government publications for the same period, and to the bulletin "The Problem of Changing Food Habits," *Report of the Committee on Food Habits of the National Research Council,* published by the National Research Council and National Academy of Sciences.

Promotion of good nutrition on an international basis, first attempted by the League of Nations, is being reorganized and much extended, and we are exchanging nutritional knowledge with our allies, in addition to lend-leasing food to them. We owe Britain an especially large debt for the example she has set in the application of principles of human nutrition under war conditions. Being faced with a food shortage, she gave free reign to her leading authorities on food and nutrition to do what they could to maintain and improve the nutrition of the British people. Many surveys of their diet had previously been made; these were extended, and the customary British diets thus determined were then fed to rats, and were improved where they were found deficient. The result has been that even under the stringent war-time controls the diet of the poor has been actually bettered, nutritional deficiences have generally decreased, and the infant mortality rate has fallen to a new low. The infant death rate has been called "the most sensitive index of social conditions." Inadequate diet of mothers and infants is one of the most important causes of a high infant death rate, as has been shown by an increasing number of studies which have demonstrated that improvement of prenatal as well as postnatal nutrition results in improved infant health and lowered death rate.

Surveys of the relation between the food eaten by school children, both at home and at school, and their state of health, have further emphasized the importance of adequate diets. Adding good school lunches or improving ones which were only fair has invariably been found to improve the physical condition of the children. At the other end of the life span, the effects of adequate diet in old age have in recent years been under active investigation. Then, too, there are many excellent reports on the relation of nutrition to the health of teeth and eyes. The British in particular have carried on large scale studies on the relation of diet to eye condition in the Royal Air Force, seeking to increase its efficiency and reduce its mortality in air combat.

Even the so-called "hard-boiled business man" has become convinced of the value of good nutrition for his employees, if for no other reason than that they do more and better work when well fed. The numerous surveys of food eaten by industrial workers, the employment of nutritionists to advise employees, and the addition of dietitians to factory cafeteria staffs, are all indicative of increasing awareness that good nutrition is vital for the good health of employees, efficiency in their work, and reduction of absenteeism.

Differentiation of Research in Human and in Animal Nutrition

Recommendations as to adequate human diets have in the past been based almost entirely on the results of experimental work with animals—usually small laboratory animals such as rats and guinea pigs. The results obtained were all too often arbitrarily reinterpreted and applied to man. Today the principles of human nutrition are being worked out by research on human subjects, and animal research (insofar as it is related to human nutrition) is used simply to furnish leads for investigations on man, or as a check in further evaluating diets actually consumed by man in everyday life. Certainly these actual diets differ markedly from the purified and limited foods generally used in nutritional studies on animals.

The setting up of tentative standards of adequacy for the food nutrients commonly deficient in the American diet, and the trial of these standards on a nation-wide basis, is a long forward step that has been taken by the National Research Council. These tentative standards are being tested and retested, evaluated and re-evaluated by actual trial, not only in the United States, but also in Canada.

Surveys in increasing number are being made of the foods which large groups of people are actually eating, and these diets are at the same time being evaluated in terms of their physiological effects. Regional customs and likes and food prejudices have also more recently come under investigation as a preliminary step toward improvement of food habits. Indirect factors such as economic status, environmental conditions, and social factors that influence nutrition have likewise come in for increased attention, with large-scale statistical studies being made of the foods actually consumed by different groups in the population. Such indirect factors may be the most important causes of extensive malnutrition among human beings, and the effect of such influences cannot of course be discovered by studies on laboratory animals living under controlled conditions.

Research on the Physiological Utilization of Food Nutrients by Man

It is increasingly evident that the amount of nutrients actually used by the body may not agree with the amounts shown by analysis to exist in a food, and that the effects are not always the same in man as in a laboratory animal fed on a necessarily

simplified research diet. The physiology of the rat, of the guinea pig, or of the dog, is not exactly the same as that of the human body. Furthermore, the diet of man is much more varied than the laboratory diets (composed of a limited number of purified food stuffs) upon which we once based such peremptory nutritional advice on the ground that certain results had been achieved by feeding certain diets to rats or guinea pigs. Nutrients are now known to influence each other and to interact, sometimes helpfully and sometimes antagonistically, so that the results of feeding a definite amount of a given nutrient may be much altered by varying the remainder of the diet. Then, too, natural foods contain, it is almost certain, still undiscovered organic substances which may be necessary for health. Many supposedly controlled experiments on laboratory animals may be vitiated by disregard of this fact, just as was the case, because of vitamin-deficiencies in the artificial diets used, in many studies made prior to the discovery of the known vitamins. The complexity and variability of the average human diet being what it is, we cannot determine exactly the part played by any single food constituent. Nevertheless an increasing amount of research is being devoted to determining the nature of the interrelations of the food nutrients in human metabolism, and this will serve at least as a helpful indication of the quantities and qualities of foods that are desirable in the human diet.

The extent of digestion of food and the amount of absorption that occurs vary with the condition of the digestive tract, both between individuals and from time to time in the same individual. The general effect of the food on the digestive tract can change the amount actually available to the body. To mention only one factor—hydrogen ion concentration (pH) — it is known that each digestive enzyme works best at its specific optimum pH, and that pH concentration also affects the solubility of minerals in the food. Iron is more soluble in an acid medium, excess calcium decreases the solubility of phosphorus, and the absorption of calcium is apparently increased with rise in protein intake. Certain foods, and substances commonly used in the preparation of foods or taken medicinally, can notably affect the digestive and absorptive processes. Thus mineral oil, taken as a laxative, or in a non-fattening salad dressing, or in commercially prepared foods (in which it is sometimes used as a war-time substitute for animal or vegetable fat or oil), decreases the absorption of the fat-soluble vitamins and of calcium

and phosphorus. Sodium bicarbonate, so commonly taken medicinally because it is considered harmless, and so often used in cooking vegetables or in excess in baking, shifts the pH of the gastrointestinal tract toward alkalinity, and so decreases the digestion of proteins in the stomach, diminishes the solubility of minerals, and destroys vitamins (notably vitamin C, ascorbic acid). It is evident that much research needs to be done on human digestion and absorption.

Studies on the intake and output (especially in the urine) of minerals and vitamins are fortunately increasing. With respect to the vitamins the situation has been complicated by the discovery that some of them may be excreted in sweat, that they may be changed to other substances while being metabolized, and that intestinal bacteria (which vary in kind and abundance in different individuals) may synthesize vitamins that can be absorbed and utilized. The physiological adjustments which the body may make to the habitual intake of a given amount of a particular nutrient over a long period of time are also under investigation.

Fortunately for the study of human nutrition, it is coming to be more definitely established and widely recognized that results obtained from animal research are directly applicable only to the species of animal on which the experiments were made. At the same time the study of human physiology as a basis for the science of human nutrition is being constantly extended through such techniques as those of blood chemistry, respiratory calorimetry, the chemistry of excretion, X-rays, post-mortem analyses, and the tracing of the paths followed by radioactive indicator substances in the body after absorption.

The Need for Better Means of Diagnosing Subclinical Nutritional Deficiences

Even when the intake of a given nutrient has been inadequate over a long period, no definitely diagnosable deficiency condition may develop. The individual may simply feel malaise, or exhibit vague physical symptoms, or may seem "just nervous" and be classified as neurotic. A deficiency may exist even without any apparent symptoms of any kind, although the individual will not be in the best of health or possess high resistance to disease. The deficiency is often revealed only by a study of the habitual food intake, and by the improvement in general health, vitality, spirits,

and resistance to infection that occurs when the diet is bettered. Many a "nerve case" has been cured by merely improving the diet. Autopsies reveal that a great many persons have had unsuspected deficiencies in diet; thus children who while living were considered non-rachitic are often found to have had rickets in mild form.

Although many such clinically undiagnosable deficiency states are being discovered through analysis of the habitual food regime, this is at best an unsatisfactory method when used alone. Fortunately diagnostic tests for deficiencies are increasing in number, delicacy, and exactness, especially in the fields of blood, urine, and fecal analysis, X-ray studies, eye examinations, and various physiological tests.

Analysis of Nutrients in Foods and Beverages as Consumed in Everyday Life

The first analysis of food nutrients were made upon raw foods—sometimes upon only a few samples, and usually upon samples all produced in the same region. Vegetables and fruits were analysed as a whole. The averages of the nutrient values obtained were then made the basis of food-value tables showing the amount of each nutrient in a given quantity of a particular food. From such tables the food values of standard servings after cooking were recalculated, with no deductions other than for loss in amount by weight due to paring, peeling, discarding seeds, etc. Today we know that the food value of cooked foods are often very different from those of the same foods in the raw state, and that different parts of the same fruit or vegetable differ in percentage composition. Minerals and water-soluble vitamins are lost both by slow washing or soaking before cooking, and by leaching into the water in which foods are boiled. Even when no water is used, the juices lost from meats, vegetables and fruits during cooking may carry with them significant amounts of the minerals and vitamins originally present, and much of the fat may be lost from meat. For this reason frying in fat, formerly considered so unwholesome, may often be the best means of preserving such food values.

Vitamins are also destroyed by heat and oxidation during cooking, and this loss is increased by the use of soda (even in the form of baking powder if the latter contains insufficient acid to completely neutralize the soda). Chopping, cutting, and

straining foods all increase the surface exposed to air, and hence aid in the destruction of vitamins by oxidation, especially vitamin C or ascorbic acid. Keeping foods hot for a long time after cooking, as on restaurant steam tables, and reheating foods, both contribute further to the losses sustained in cooking. In the preservation of foods vitamin values are reduced by drying, by freezing, and to a much smaller degree by canning (but smaller only if the canning is done in a closed container with no oxygen present). Some of the enzymes present in raw foods also destroy vitamins—slowly in the case of stored fruits and vegetables, more rapidly when the foods are heated gradually in cooking. Light shining on milk, whether in or out of the bottle, lowers the riboflavin content.

On the other hand, research has shown that drinking water and the water used for cooking vegetables may be important sources of minerals that are not taken into account in the food tables; that foods may gain in iron content from the vessels in which they are cooked; that minerals (with some riboflavin and niacin) are found in meat extracts; and that tea contains some riboflavin, coffee some niacin, and beer and ale some of both of these vitamins.

Laboratory Standards of Accuracy Misleading in the Study of Human Nutrition

Just as we formerly based nutrition recommendations for man directly on experiments made with rats and guinea pigs in the laboratory, so we also took the meticulously exact laboratory techniques of weighing and decimal calculation into our diet kitchens and our studies on human nutrition, and used them in planning normal and therapeutic diets. We blissfully ignored the possible losses or changes in food values due to cooking, or were unaware that such changes may occur. We made no allowance for variation between individuals in the amounts of particular nutrients absorbed, nor for the physiological differences between man and the various animal species used in nutrition experiments. We did not dream of the importance of essential elements like copper and cobalt, which affect iron utilization, nor of the existence of eleven vitamins of the B-complex and heaven knows how many more to come. The difference between the limited and purified diets fed to the laboratory rat and the non-limited, nonsterile, enormously varied diets of man did not enter our calculations, nor did we realize that soil water, fertilizer, stage of ripeness-

and variety of a particular vegetable or fruit may cause great variation in the amounts of specific nutrients present. We lived in a happy but completely unreal heaven of illusory "scientific accuracy," and to top it off we made the application of nutritional principles so difficult that in practice they were generally ignored.

Now we realize that research in human nutrition must be based on the foods that we actually eat, in the form in which we eat them; that it must consider *human* physiological requirements rather than those of the rat or guinea pig; and that to be effective it must be adjusted to existing conditions, and be simple and practical in its applications. Research on laboratory animals can often point the way for studies on human nutrition; but the only highroad to improvement of man's health through better diet is by research in *human,* not in animal nutrition.

DEVELOPMENTS IN WOOD USE

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All of us are familiar with wood—in fact, too familiar. We are content with whatever concepts we have developed from personal experience. When you say wood to a farmer, he thinks in terms of fuel, fence posts and stack poles. When you say wood to the forester, he thinks in terms of trees and saw-logs. To the building contractor or construction man, wood means timber, 2 x 4's, flooring and siding. To the manufacturer it means furniture or some other finished product. In recent years, a new figure has come into the field of wood use. This is the chemist, who is not limited by the known facts but whose urge is to reduce all things to their essential elements and study conversion possibilities.

This interest of chemistry in wood has been greatly stimulated by the demands of war, and the results are nothing short of amazing to the layman. I do not mean that all of our chemical research in wood as a basic material has occurred since Pearl Harbor, but I do mean that the information and practical applications which existed in the scientific laboratories prior to that time might have been several generations in coming into general use in the normal course of events. War has caused us to peruse these scientific findings with greater interest and with a view to immediate application. At the same time, scientific research into further possibilities of wood as a basic material has been greatly accentuated since the beginning of and because of the war.

Looking into postwar implications, one observer has remarked that the principal benefits for peace time use will be in terms of the three "P's"—plywood, prefabrication and plastics. Actually, the major research has been along five channels, namely: (1) preservation, (2) drying and seasoning, (3) reassembly, (4) chemical conversion, and (5) alteration of mechanical properties.

The first two of these are of rather long standing. Man has endeavored for a long time to find ways and means of preserving wood against sap stain, fire, insect damage, rot, and chemical attack. The control of sap stain has been pretty generally attained and all of our larger mills have provisions for dipping their green

lumber in a chemical solution prior to its going to the drier sheds, thereby eliminating the occurrence of the stain.

Fireproofing consists of injecting heavy concentrations of fire retardent chemical salts into wood either through temperature control, by vacuum or by pressure. Silicon is one of the principal chemicals used. We have wood today that will char when exposed to high temperatures for a sufficient length of time but which will completely prevent the spread of flames. Since Pearl Harbor, the use of such wood has increased over 300 percent. The Federal Government has been the big buyer but the fact that it has specified fireproof timbers in the construction of aircraft hangars, blimp hangars and the like, has taught many of our architects and engineers for the first time that such material is to be had—and we shall see it recommended and used much more generally in civilian construction after the war.

Research is going forward in the fireproofing of wood by coating. We know that the effectiveness of such coatings depends upon their type, their thickness, and the conditions of the fire as determined by the design of the structure, presence of drafts, size and duration of the fire, and similar factors. I believe that boron has thus far proved one of the most effective ingredients of such fireproof coatings.

To a large extent, preservation of wood against insects has gone hand in hand with its preservation against decay. The use of creosote as a deterrent to the ravages of both insects and fungi is generally known. There are, however, several other chemicals that are proving equally effective and various methods of applying the preservatives are being tried. We have reached the point where fairly good results are being attained without the cost of pressure treatment, the preservative chemical being simply applied by brush. The best report of comparative tests, in my judgment, is to be found in the "*Tenth Annual Report of Wood Preservatives in the Mississippi State Highway Department's Test Gardens,*" Jackson, Mississippi, released in July, 1943.

The second major field of wood research is drying and seasoning. When wood dries considerable shrinkage occurs across the face. Some occurs radially and little longitudinally. As the outside zones of the wood cross-section dry, the fibers shrink, setting up internal stresses against the interior cells which have not kept pace in the drying process. This causes warping or cracking of the boards, and, in boxed-heart timbers, results in checking or splitting that frequently makes the timbers useless

for the purposes for which they were cut. In fact, large timbers must often be seasoned for several years in order to become thoroughly dried, and by that time half or more of the pieces may have been rendered useless.

There are three possibilities for the elimination of such waste. By chemicals, we may control the rate of outside or face drying. Or we may fill the pores of the outside wood with solidified chemicals so as to prevent their shrinkage. Or we may so strengthen the wood fibres chemically that they are able to withstand the stresses that normally would cause cracking and checking.

Whatever chemical is employed, it must be something inexpensive, be highly soluble in water in a stable form, be noninjurious to the wood fibre, have no corroding effect on woodworking tools, and produce no "sweating" in humid weather. Thus far, urea has proved to be the most effective chemical substance. In addition to minimizing the checking from drying, it also provides some degree of stain proofing, decay resistance, and fire resistance. The quantity used depends upon the species and the size of the timbers. It may be scattered on the outside face of the wood as dry crystals or the wood may be dipped in a urea solution. Urea does not materially hasten the drying time of lumber that is stacked in the open air but it does make for better quality and better finished grade of products. In kiln drying, it minimizes the risks of fibre failure, thereby permitting a faster kiln schedule and increasing the output of the kiln unit. The application of urea is primarily to green lumber, and the urea treated zone on the outside of the particular board is eventually removed after seasoning when the board is dressed and made into flooring, siding or some finished wood product.

The third field of wood-use activity is that of reassembly—taking wood apart and putting it together again in some new form. We are all familiar with sawdust plastics, in the form of wallboard or press board, which are on the market under various trade names such as Insulite, Masonite or Temboard. Equally well known is the use of wood fibre in the making of paper. The ordinary kraft paper is in common usage for grocery bags, wrapping paper, cardboard boxes and containers, and for the news print on which our daily paper is printed. Less familiar is its use in shipping bands for bombs, G. I. helmet liners, bazooka barrels and the like.

We are all familiar with plywood, which consists of very thin sheets or slices of wood, glued together in such a way that the

grain of one layer is at right angles to that of its neighbor. Through the use of plywood, we effect a saving of wood, we gain strength, we create great sheets of wood wider than we could saw from the trunk of a tree, and we save in handling costs and shipping charges. The greatest limitation on plywood has been the failure of even the best glues to withstand moisture and heat changes. The use of synthetic resins instead of glue as bonding materials has greatly augmented the possibilities of plywood. We can now give plywood not only a high degree of moisture resistance, but resistance to heat as well. Further, through the use of the resin bond and its adaptability in the manufacturing process, we can mold plywood into almost any shape or form. Our PT boats are sufficient evidence of the resistance to water of this resin-bonded plywood. The fact that 65% of Britain's airplane construction, including Wellington bombers and Spitfires, is of plywood, is evidence of its adaptability to bending and shaping. The 75-foot radio mast standard in the U. S. Signal Corps today consists of seven layers of veneer, resin-bonded, and is fireproof, bug-proof, and weather-proof. It comes in sections and can be assembled in 20 or 30 minutes. The whole thing weighs 250 pounds and replaces a steel mast that weighed 1900 pounds.

A somewhat similar development that owes its advance to the resin bond has been called lamination. In this case we do not use thin sliced sheets of wood veneer but sawn boards. We can lay these boards end to end to whatever length is desired, and can build tier on tier, breaking joints just as does the brick mason in building a wall. By using the resin bond, we have, when we are finished, a timber that, though assembled from smaller pieces, is stronger than if hewn from a solid piece. The size of wooden boats that we could build has been limited by the size of tall, straight trees that we could find to hew into keels. Today we can make a keel of any width, thickness, length, and even shape desired, and have it stronger than one hewed from a single tree. Lamination has made possible the largest wooden structures in the world today. These are series of blimp hangars that have been constructed on both the east and west coast in connection with submarine patrol. The one at Richmond, below Miami, is over 1000 feet long, over 300 wide, 185 to the peak of its roof, and contains no posts, supports or trusses. It is framed of laminated arches that begin at the foundation and meet at the top.[1] In

[1]This structure was destroyed by fire during the hurricane of 1945.

the last six months there has come into existence on the west coast a new firm that calls itself "Big Timber, Inc." and guarantees to make a timber of any desired width or thickness up to a half mile long.

The fourth major field of research activity, chemical conversion, is a large and fruitful one. Wood is roughly 70% cellulose and 30% lignin, with rarer elements normally totaling less than 1%. By chemical conversion, cellulose is made into explosives, rayon, cellophane, sugar, starch, carbohydrates, and numerous other derivatives. Prior to the defeat of the Germans about 85% of all the textiles in Germany were created from wood fibre. About 65% of the sugar supply of the German people was coming from sawdust, and the dairy and beef herds which kept German armed might in the field were fed on millions of tons of synthetic cow fodder made of sawdust by way of the sugar process.

Lignin, which is still something of a mystery to the chemists, is recognized as a protein. From it comes our synthetic or artificial vanilla flavoring. From it come adhesives and an endless variety of plastics. In Germany, synthetic oils and heavy lubricants, and even concentrated protein foods, have in recent years been processed from it.

Through the chemical distillation of wood, we secure methyl alcohol, acids, tannins, charcoal, wood tar, wood oils, and various dye materials.

In fact, chemical conversion is almost daily opening whole new avenues of use for wood. These advances are so rapid that only through trade journals and research papers is it possible to keep abreast of developments.

The mechanical properties and possibilities for use of most commercial wood species have been rather thoroughly established through trial and error, as well as by standard tests. In the past, it has been recognized that the use to which a particular wood is best adapted depends upon properties which, in turn, are determined by its structure. The structural weaknesses of most woods have been gauged and the fact of their shrinkage or expansion, according to humidity and moisture conditions, recognized as a limitation. Wood is a porous material and, even when its pores are filled with resin solutions such as lacquer, continues to react in the normal way. However, if the pores are filled with a resin-forming chemical which reacts with the cellulose of the

wood, we achieve dimensional stability and a product that is much harder than wood, wears better, takes a high polish, and is stronger in all directions. In fact, we have a new material for which wood has become the skeleton. By impregnating wood with these resin-forming chemicals and at the same time subjecting it to heavy compression, we reduce the volume of the wood layers involved but retain all the resin and solid wood fibre that it contained. Out of this process has come a new material to which has been applied the name "compreg." A material of great density, it has about the same specific gravity as coal. Almost scratch proof, it has a high degree of resistance to alcohol or ordinary corrosives. It is three times more resistant to heat than ordinary steel and is comparable to steel in strength. It can be sawed, drilled, turned, tapped and threaded. We are already using it for bearings and gears where formerly we considered tool steel necessary. It makes a soundproof gear and as a bearing requires only a water lubricant. The several firms that are making it today under government patent are all under war contract. Among other things they are producing aircraft carrier decking, bases for radar antennae, oil line brackets for airplanes, and the best airplane propellers available today. The latter consist of some 20 odd layers of wood put together with the resin impregnation at 2000 pounds pressure to the square inch. The resultant material is about half the original thickness of the wood. It does not have to be ground into shape, but is molded or pressed into the form desired. Already various furniture companies have plans for this material. In the future, when Junior saws the piano leg it will not be necessary to refinish the piano. We shall merely remove the scratch by rubbing and buffing, for this material is the same all the way through. The curse of the furniture industry today is doors and drawers that swell and bind in wet weather. If they are made of compreg, or even faced with a thin sheet of compreg, moisture is shut out and a degree of fire resistance provided as well.

Another development that is carrying wood beyond its natural limitations is the use of urea in bending. It has been found that when green or wet wood is impregnated with a urea solution and raised nearly to the boiling temperature, it becomes highly pliable. On cooling, it regains its rigidity but keeps the shape that was given to it. It can again be softened by heating, and flexed or bent to some other shape. If both urea and dimethyol urea are used, and the wood is heated to two levels before being

bent or flexed into shape, it will not be subject to change when reheated and becomes fixed in the form given it.

The possible contributions of these various developments to the comfort and convenience of man are obvious. From the standpoint of forest resources the implications are also of great importance. The necessity for growing trees of large proportions, which require two or three human generations to produce, is practically eliminated. Trees that have been regarded as weed species because of the natural weaknesses or limitations of their wood now assume commercial importance through chemical conversion or some treatment that modifies the wood's natural properties. Finally, wood waste can be reduced to a minimum, and where we have been using only 25% of the average tree in the past, we can look forward confidently to the utilization of 75 to 90% of the tree's tissue. One scientist has said that we are coming into the Plastic Age. Rather, I should say we are coming into the Age of Wood—and with it will come an industrialization throughout Florida's 22,000,000 acres of timber land that is far beyond the expectations of our people today.

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SEAWEED UTILIZATION IN SOUTH FLORIDA[1]

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The marine algae or seaweeds are one of the abundant natural resources of potential economic importance in south Florida. The marine algae of the world are used for foods, drugs, gums, chemicals, stockfeed, and fertilizer. Florida algae show particular promise as sources of fertilizer, stockfeed, alginic acid, and agar.

FERTILIZER

Analyses of soils in south Florida reveal serious deficiencies in many of the mineral elements essential for plant growth and human nutrition. The seaweeds which are washed up in large quantities on our shores are excellent sources of the major fertilizer elements, nitrogen, potassium, and phosphorus, as well as the many elements required in minute quantities for normal plant and animal growth. The marine plants have absorbed these elements from the seawater and greatly concentrated them.

Seaweed fertilizers supply not only minerals, but, in addition, valuable organic matter which aids in retaining water and minerals in the upper levels of the soil where plant roots can absorb them. Another advantage of seaweed fertilizers is that they lack the undesirable weed seeds and fungus spores found in manure.

The pioneer farmers in south Florida used seaweeds with great success. During the present fertilizer shortage, it is particularly desirable to make full use of this natural product found on our beaches.

STOCKFEED

The seaweeds, whether used alone or mixed with other materials, supply an important addition to the often inadequate diet of South Florida dairy and range cattle, chickens, and other animals.

ALGINIC ACID

The commercial importance of seaweed gums has increased rapidly in recent years because of their ability to form mucila-

[1] Investigation sponsored by the Science Research Council of the University of Miami.

ginous sols or firm gels, even in low concentrations. Alginic acid and its soluble sodium salt, algin, probably occur in most brown algae. The former is a colloidal polyuronic acid composed of d-mannuronic acid anhydride units linked glycosidically in the pyranose ring structure (Steiner, 1941). It is now extracted commercially from several species of large kelps on the Pacific and North Atlantic coasts (Scheffer, 1943).

Algin finds an ever-increasing number of uses as a stabilizer in ice cream, cheese, and dried milk, in cold water and emulsion paints, and in printing inks, cosmetics, lotions, tooth pastes, car polishes, glue, and pastes. The free alginic acid and its insoluble metallic salts are used in fireproofing and waterproofing wood, fibers, and fabrics including camouflage materials, and in can-sealing compounds. It is used in transparent films and foils, as a base for plastics, as a clarifying agent in the sugar industry, as a creaming agent in the treatment of latex, in finishing leather, and as a dental impression material.

None of the true kelps of the family Laminariaceae occurs in southern Florida. However, the abundant gulfweed, *Sargassum*, has been shown to contain alginic acid (Humm, 1942). Further investigation is required to establish the commercial practicability of its extraction from gulfweed. Important by-products of the commercial process include the valuable chemicals, potassium chloride, bromine, and iodine.

Agar

The most promising product from Florida marine algae is agar. Tseng (1944a) has defined agar as "the dried amorphous, gelatin-like, non-nitrogenous extract from *Gelidium* and other red algae, being the sulphuric acid ester of a linear galactan, insoluble in cold but soluble in hot water, a dilute neutral solution (1 to 2%) of which sets, upon cooling, to a firm gel solidifying at 35° to 50° C., and melting at 90° to 100° C." Aside from the fact that commercial agars usually melt between 70 and 80° C., this definition is an improvement over the broader definitions which include carrageenin and other red seaweed extracts with different properties which Humm (1944) calls "gelose."

Complete information about agar, including its history, production, and uses has been published recently by Tseng (1944a, 1944b). Like alginic acid, agar finds an ever-increasing number of uses as a solidifying agent in media for the growth of bacteria,

fungi, algae, and orchids; as a dental impression material, in laxatives, emulsifiers, bread, pastry, confections, ice creams, sherbets, water ices, desserts, salads, and jellies. It is used in the packing and preservation of meat and fish, in sizing of silk and paper, in the lubricant for drawing tungsten wire, as a supporter of the emulsion on photographic film, in marine storage batteries, and in cosmetics. It is used as a mold in casting artificial hands for wounded service men, and in wound dressings.

The tremendous importance of agar, and the fact that 92% of the 650,000 pounds used in the United States in 1941 was imported from Japan and China, impelled the War Production Board to restrict its use to the essential bacteriological media when the oriental supply was shut off by the war. About 16% of the agar required in the United States before the war was used in media. To meet the urgent demand for this critical material, the small California agar industry expanded rapidly under the stimulus of much higher prices for agar. At the same time, marine botanists all over the world began an intensive search to discover new sources of agar among the numerous species of red algae occurring along the shores of their own countries. On the Atlantic coast, investigations of Humm (1942, 1944) at the Duke University Marine Laboratory led to the establishment of two commercial processing plants at Beaufort, North Carolina, using the red seaweed, *Gracilaria confervoides* (L.) Greville. Humm has also published (1944) data on certain seaweeds collected in Florida, mostly on the west coast. Following his surveys, Citrus Concentrates, Inc., of Dunedin, Florida, has been experimenting with agar production from various species in the Gulf of Mexico from Tampa Bay southward, but has not yet attained commercial production (Skinner, *in litt.*, Oct. 9, 1944.)

Scientists in the laboratories of the Institutum Divi Thomae at Palm Beach and Cincinnati, Ohio, have been working on various species of algae on the lower east coast of Florida, especially in Lake Worth and the Indian River. Their results, as yet unpublished, were utilized by a Cincinnati manufacturing company, Sperti, Inc., to start agar production from *Gracilaria* collected in the Indian River near the village of Jensen, just north of Stuart. This company operated a small collecting and drying plant in the winters of 1942-43 and 1943-44 and shipped the dried seaweed to their pilot plant in Cincinnati for extraction of the agar. It planned to build a processing plant near Jensen and to go into

large scale production in the winter of 1944-45. Another company is also establishing a processing plant in that same area.

The urgent demand for agar has emphasized the need for intensive investigations of our neglected seaweed resources. Surveys of the distribution of the larger seaweeds and their seasonal abundance and availability must precede any commercial utilization. The physical and chemical composition of the plants and of compounds extracted from them should be systematically studied. Improved methods of extraction may more than double the yield of these compounds. It should be possible, in the light of better knowledge of the properties of these compounds, to develop new uses for them in the food, drug, and technical industries.

Seaweed Investigations in South Florida

The remainder of this paper is a progress report on the results of investigations of Florida seaweeds which are potential commercial sources of agar.

Distribution: Limited surveys were made of the Indian River from Ft. Pierce southward, of Biscayne Bay, Blackwater Sound, Little Blackwater Sound, Long Sound, the northeastern part of Florida Bay, and of both sides of the Florida Keys as far as Lower Matecumbe Key. The more abundant species were analyzed for agar or gelose content.

The only area on the lower east coast of Florida where agar-bearing red algae are sufficiently abundant for commercial use is in the Indian River north of Stuart, and here only for about eight months of the year, from October through July. The dominant species there are *Gracilaria blodgettii* Harvey and *Gracilaria lacinulata* (Vahl) Howe [=*Gracilaria multipartita* (Clements) J. Agardh]. A similar conclusion was reached by Humm (1944) from his own surveys.

Growth Experiments: Because commercial quantities of agar-bearing species were absent from Biscayne Bay near Miami, a series of experiments was conducted to determine if the desired species could be "planted" and grown successfully. The species chosen for this was *Gracilaria confervoides* (L.) Greville, which Humm (1942, 1944) had found the best source of commercial agar and which is also being used in California (Tseng, 1944a, 1944b) and elsewhere. Living specimens shipped in seawater by Humm from the Duke University Marine Laboratory at Beau-

fort, N. C. were tied to various piles and stakes in shallow water at 16 different locations under a wide variety of ecological conditions in Biscayne Bay.

The best growth was obtained from late September to January with specimens tied to stakes in the clear flowing water of full salinity in Norris Cut, north of Virginia Key. One specimen, a slender branched filament seven inches long, multiplied its weight over eight times in 16 days. After 93 days, it had grown into a densely-branched mass 16 inches in diameter and over 118 times its initial weight.

These experiments also demonstrated that this species would not grow vigorously here in turbid or muddy water, nor in contact with piles or other objects which already supported a growth of marine animals and plants. There was evidence that some of the specimens were eaten by animals, decomposed by bacteria, or killed by diatom and colonial bryozoan infestation.

Repeated attempts to grow tied specimens of this species and also of *Agardhiella tenera* (J. Agardh) Schmitz, in the same favorable location in June and July, failed completely. It is not yet established whether this was the result of the natural annual cessation of growth in these species or the result of the high water temperatures (86-90° F.) which might be unfavorable for algal growth or too favorable for the great variety of contaminating organisms which either feed on the algae, or, by their presence on the surface, reduce the light intensity below the compensation point.

Further experiments are required to develop methods of growing *G. confervoides* economically, perhaps in large enclosures.

Composition: Seven species were selected for analysis because of their abundance or suggested agar content. *Gracilaria blodgettii* Harvey was collected in late July in a cove on the east side of the Indian River just south of the bridge at Jensen. *Gracilaria lacinulata* (Vahl) Howe [=*Gracilaria multipartita* (Clements) J. Agardh] was collected in early July from the rocks on the west side of Biscayne Bay at N. E. 17th Terrace, in Miami. *Agardhiella tenera* (J. Agardh) Schmitz was collected at the same time and place as *G. lacinulata*. *Digenea simplex* (Wulfen) C. Agardh, was collected in mid-July along the north side of the new highway fill across Lake Surprise on Key Largo. *Laurencia poitei* (Lamouroux) Howe, was collected in mid-July on the west side of Biscayne Bay at Cutler. *Laurencia papillosa* (Forskal) Greville, was collected

in mid-July in Hawk Channel at Upper Sound Point on Key Largo. *Eucheuma isiforme* (C. Agardh) J. Agardh, was collected in mid-July on the south side of the new highway fill across Lake Surprise on Key Largo.

The specimens were brought to the laboratory in seawater in wooden buckets. Samples were drained and weighed, then dried on a screen over electric light bulbs to constant weight for dry weight determination. All data are summarized in Table 1.

For the determination of agar or gelose content, 200 gm. fresh or 20 gm. dried algae were thoroughly washed in fresh water to remove some of the salts, drained, heated with 700 ml. distilled water in a two-liter erlenmeyer flask in a pressure cooker for 30 minutes at 15 pounds pressure (temperature about 121° C.). In one case, a duplicate sample was also boiled in an open beaker for one hour, with distilled water added to replace that lost by evaporation. The hot mixture was filtered through heavy, unbleached muslin cloth and the residue again extracted by the same method. The combined filtrates were cooled and frozen overnight in ice trays. The blocks were then allowed to thaw in air on a course mesh wire screen, so that the water dripped through taking with it mineral salts and other soluble impurities. The agar or gelose which remained on the screen was dried to constant weight in an oven at 40° C.

Physical Properties: The gelation and melting temperatures are particularly important if the agar is to be used for bacteriological media. The best agar melts at about 80° C., but then remains liquid when cooled to about 38° C. This enables the technician to mix organisms with it uniformly while still liquid at a temperature of about 42° C. without injuring the bacteria. Then it is poured into a petri dish to become a firm gel at room temperatures even in very warm climates. Gelatin is less satisfactory because it melts at a much lower temperature and also is digested by many bacteria.

The gel strength is important to the technician because he requires a firm, almost rubbery surface over which to streak bacteria to obtain separate surface colonies. The firmness of the gel even in warm climates is the particular physical property which makes agar so useful for so many purposes.

For the determination of gelation temperature, melting temperature, and gel strength, 1.5 gm. of the dried agar or gelose was mixed with 100 ml. of distilled water and heated in a bath

of boiling water until melted and suspended uniformly. (Much of the extract of three samples failed to go into solution even after several hours heating in the water bath or in the pressure cooker. No satisfactory explanation for this could be found.

TABLE I—COMPOSITION AND PHYSICAL PROPERTIES

Genus and Species	Dry weight as per cent fresh weight	Per cent water	Agar or gelose		Gelation temp. °C.	Melting temp. °C.	Gel strength	
			Per cent fresh weight	Per cent dry weight			Weight supported gm.	Per cent of commercial agar
Gracilaria blodgettii ... fresh, pressure	10	90	2.4	24	27	55	7.4	27
Gracilaria blodgettii ... bleached, pressure	.....	.....	2.9	29	17	42	6.6	24
Gracilaria blodgettii ... fresh, boiled	.....	.....	2.0	20	.....	.....	.....	.....
Gracilaria lacinulata..	10	90	1.5	15	43	88	24.5	90
Agardhiella tenera.....	7	93	0.85	11.6	36	41	2.4	9
Digenea simplex.....	15	85	0.27	1.8	32	66	6.6	24
Laurencia poitei.....	18	82	1.22	6.8	.....	.....	.....	.....
Laurencia papillosa....	.....	.....	0.26	.....	.....	.....	.....	.....
Eucheuma isiforme.....	.....	.....	0.43	.....	.....	.....	.....	.....
Commerical agar..... (Difco, technical, U.S.P.)	.....	.....	.....	.....	36	78	27.1	100

As would be expected, these samples did not gelate even at temperatures as low as 4° C.).

Determinations of gelation temperature and melting temperature were made on the 1.5 per cent solutions, using a method suggested by Humm (*in litt.*, Aug. 16, 1944). Hot melted agar was poured into small test tubes of 9 ml. capacity, to a depth of 4 cm. Four of these were placed in a wire holder in a one-liter beaker of water which was cooling slowly. Thermometers were used in the bath and one tube of agar. A capillary pipette made from a dropper was used to introduce small bubbles of air near the bottom of the tubes. The temperature of the duplicate agar tube

at the time when bubbles just failed to rise in the other tubes was taken as the gelation temperature.

The temperature was then lowered at least 5° C. to enable the gel to become firm with the bubbles in it. Then the water bath was heated slowly until the bubbles rose to the surface. This temperature was taken as a melting temperature.

The gel strength was determined using a modified Lipowitz meter, described by Kizevetter (1937). A firm rubber hemisphere, 10.1 mm. in diameter, was driven through the surface of the gel in a petri dish at 24° C., by adding weights gradually to a cup attached to the hemisphere. The figures in Table 1 are averages of three determinations on each sample. The gel strength of each sample is also expressed in the last column as a percentage of the gel strength of commercial agar.

Comparison of the data in Table 1 leads to the conclusion that *Gracilaria lacinulata* most closely approaches commercial agar in these three important properties. With the other species, it is necessary to use a concentration higher than 1.5 per cent in order to obtain the firm gel required for most purposes. Some of these extracts produced gels so soft that they should be called "gelose" instead of agar.

The three different treatments of *G. blodgettii* appeared to influence the properties of the extract. Drying and bleaching in sunlight seemed to lower the gelation and melting temperatures. Boiling in an open beaker seemed to destroy the gel-producing power of the extract. Further study will be necessary to reveal the mechanism of these changes and suggest methods of avoiding them. Both the fresh and bleached samples gave a final product with a satisfactory light gray color, which suggests that the long drying process may be omitted if the extracting plant is located near the collecting grounds.

Many problems which require further study have developed in the course of these investigations. More detailed surveys should be made to discover all areas of commercially abundant agar-bearing species. More complete data on seasonal distribution, growth, reproduction, and life history of these species must be obtained. Careful study of the influence of pH on the completeness of the extraction and properties of the extract should be made, since Tschudy (1943) reported that yield and quality of agar from California species are influenced by the pH of the extracting solution. Determinations of the concentration of gelose from different species required to give gel strength equal to that of

1.5 per cent commercial agar should be made. Determination of the water of syneresis in the extracts should be made. Chemical treatments which improve the qualities of the gelose extracts should be fully explored. Careful studies of the cost of harvesting and processing relatively small quantities should be made before undertaking large-scale operations, because considerable decrease in the price of agar is to be expected owing to the end of the Pacific war.

Until these and other problems are solved, commercial development of Florida's seaweed resources should be undertaken cautiously and with full knowledge of the difficulties to be expected.

Summary

The marine algae or seaweeds are one of the abundant natural resources of potential economic importance in south Florida. Utilization of Florida algae for fertilizer, stockfeed, alginic acid, and agar requires extensive scientific investigations on the distribution, growth, abundance and composition of the plants, and on the properties of their products.

This paper is a progress report on the results of investigations of Florida seaweeds which are potential commercial sources of valuable agar. Surveys indicate that the only area on the lower east coast of Florida where agar-bearing red algae are sufficiently abundant for commercial use is in the Indian River north of Stuart for about eight months of the year. Growth studies on specimens of an agar-bearing species now used commercially in North Carolina proved that it can be grown rapidly near Miami in the winter months.

Several of the most abundant red algae of south Florida were analyzed for water content and agar or gelose content. The agar or gelose extracts were studied for the important physical properties of gelation temperature, melting temperature, and gel strength. These properties of some of them approached those of commercial agar. Further investigations which may lead to practical commercial utilization of these algae are outlined.

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THE IDENTIFICATION OF OAT VARIETIES BY SEED CHARACTERS

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The maintenance of varietal identity and purity in oats has been a perplexing problem for many years. Too many farmers believe that "oats are just oats," and have little appreciation of the meaning of pure seed stocks and varietal adaptations.

Until recently a sufficient supply of good quality home-grown seed of adapted varieties has not been available in the South, and, because of the prevalent ignorance of oat varieties, farmers frequently plant lots of mixed seed and varieties which are not suitable for this section of the country. Mixed oats are not profitable to the farmer because the different varieties have different maturity dates. Also, the mixtures often contain oats which are unsuitable for southern cultivation.

The State Department of Agriculture is interested in making available to the farmers better seed, true to variety and of known breeding. Since 1941 much progress has been made in improving the quality of seed oats sold in Florida, for at this time a regulation was added to the Florida Seed Law prohibiting the sale of mixed varieties.

Although oat varieties can be readily identified by the plants in the field, the seeds of different varieties are so similar in appearance that it is almost impossible for a farmer to recognize a mixed lot when buying oats for planting. The control of the quality of seed oats therefore depends on inspection and sampling, and on identification of the seeds before they are sold. It has, therefore, been necessary to devote a great deal of time to the study of seed characteristics by means of which oat varieties can be distinguished in the laboratory. These characteristics have to a certain extent been described in literature, but they have not been assembled and reduced to the form of a practical key. We have had to find out what characteristics are diagnostic, and outline them into a form suitable for our use.

Cultivated oat varieties fall into two groups, which correspond to the two species *Avena sativa* and *Avena byzantina*. Varieties of *Avena sativa* constitute the northern group, which consists of white, gray, and black oats. Varieties of *Avena byzantina* constitute the southern group, which consist of the red oats. With

a few exceptions the northern oats are not suited for southern cultivation. For this reason only a few details concerning their identification are given here.

Northern Oats: All of the varieties of northern oats are readily distinguished by their characteristic coloration. The main identifying feature of *white oats* is their creamy white color. Plate 1 (figs. 1, 2) shows the other characters by which they can be recognized: the narrow, slim outline, the inconspicuous seed scar, the long rachilla, the inconspicuous lines, and a callus which is turned up and pointed. The coloration of *gray oats* (Plate 1, fig. 3) is also distinctive, and their grayish striped appearance is the only feature needed for their identification. The grain is gray with conspicuous light-colored veins; no other variety of oats has this appearance. *Black oats* (Plate 1, fig. 4) are shiny black in color. They have a long rachilla, inconspicuous veins, and a callus which is squared rather than pointed. Weathered oats of other varieties may sometimes be black, but they never have the shiny, lacquered appearance of true black oats.

Southern or Red Oats: The red oats, which constitute the southern group (*Avena byzantina*), are distinguished from all members of the northern group by their distinctly reddish-brown color. On the basis of other seed characters they fall into two sub-groups: the Red Rust-resistant Oats (Plate 2) and the Other Red Oats (Plate 3).

These two groups of red oats may be distinguished by several characteristics. Although both are reddish, the grains of Red Rust-resistant Oats are brownish red or dark red, while those of the Other Red Oats are yellowish red or rich buff. Red Rust-resistant Oats have two florets, the Other Red Oats three florets. The grain of Red Rust-resistant Oats is longer, and appears slim and narrow in contrast to the broad and plump appearance of the grain of the Other Red Oats. Perhaps the most prominent character distinguishing Red Rust-resistant Oats is the large, open basal scar that is sometimes called a "suckermouth." This basal scar is small and less conspicuous in the Other Red Oats. When a secondary oat of Red Rust-resistant Oats separates from the primary, the break is near the base of the first floret, so that the rachilla remains on the second grain. In most of the Other Red Oats this break is near the base of the second floret, and the rachilla remains on the first grain. Red Rust-resistant Oats have rather prominent awns. In the Other Red Oats awns are rarely

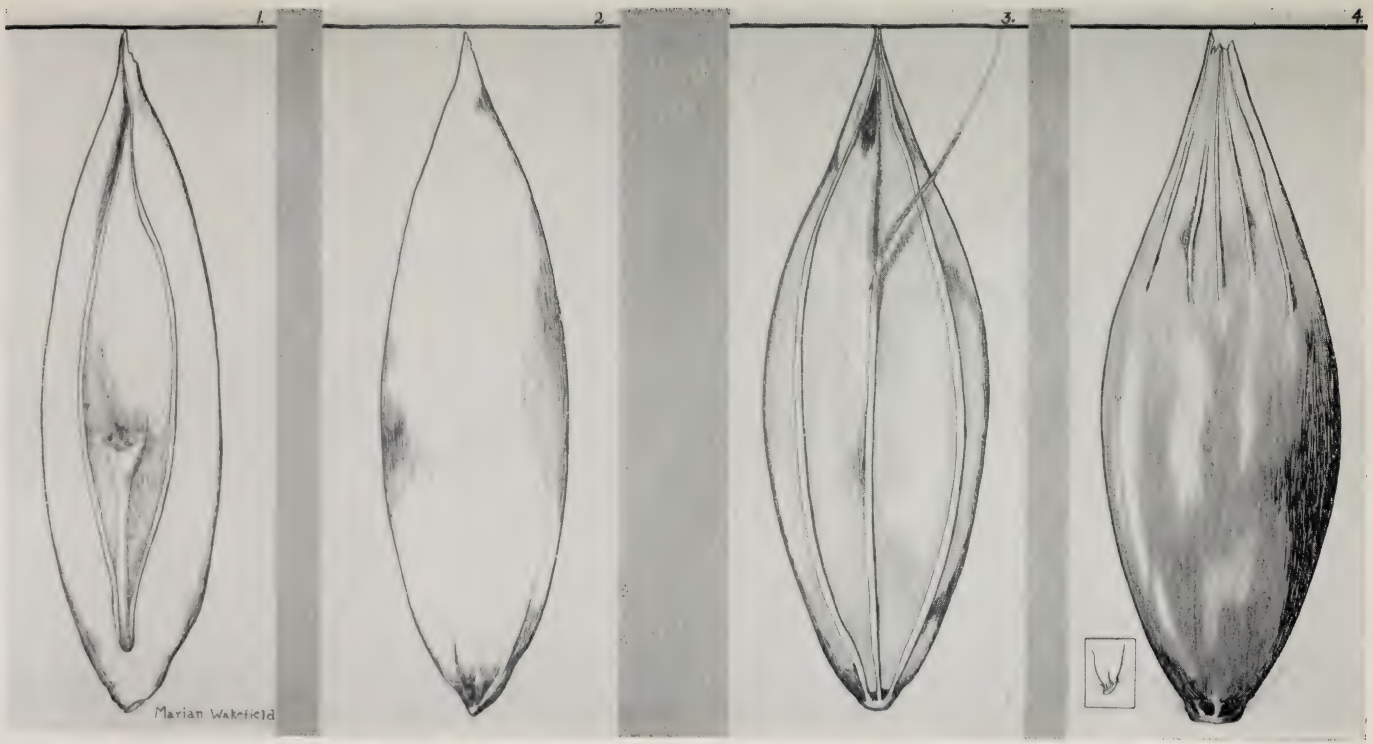

Plate 1.—Northern Oats. 1, 2, White oats: 3, Gray oats; 4, Black oats.

Plate 2.—Red Rust-resistant Oats. 1, the entire spikelet, with only two florets; 2, 3, two views of the first grain; 4, the second grain.

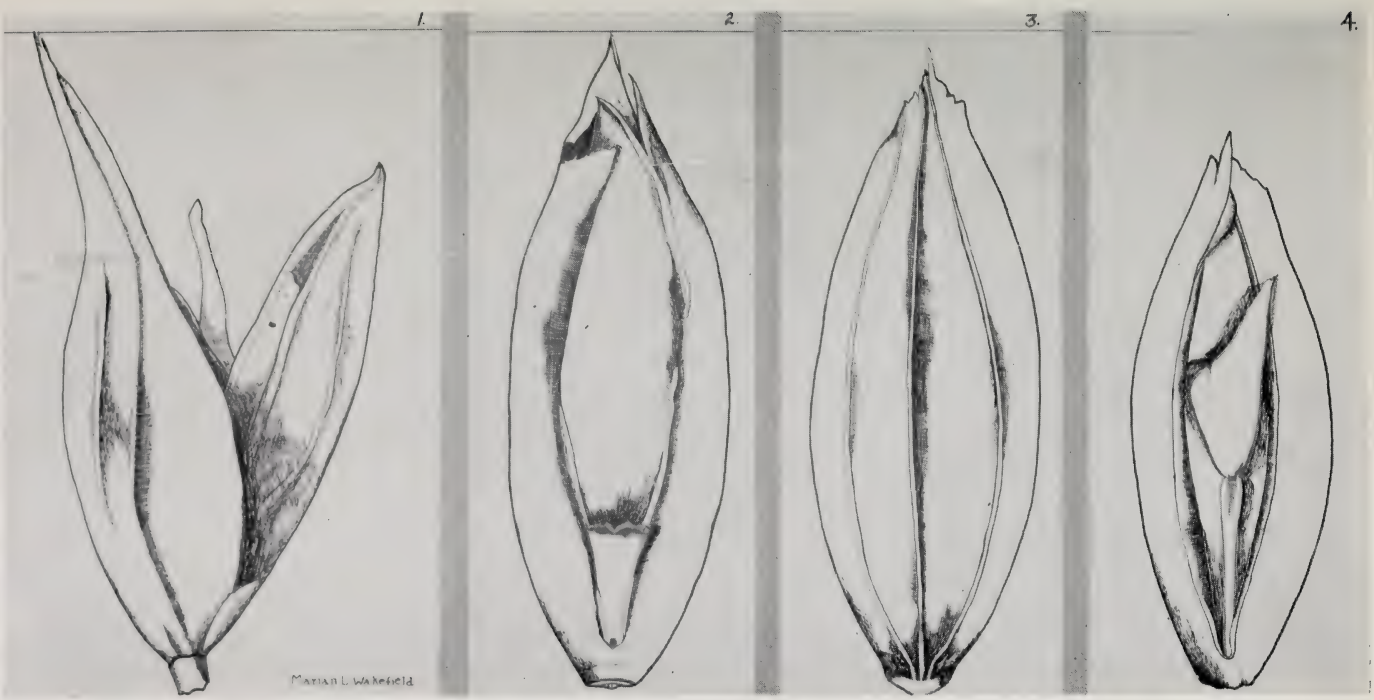

Plate 3.—Other Red Oats. 1. the entire spikelet, with three florets; 2, 3, two views of the first grain; 4, the second grain.

Plate 4.—Wild Oats and "Off types" of Cultivated Oats. 1, 2, Wild oats; 3, False wild oats; 4, Heterozygous wild oats.

present, and when they do occur they are less prominent. Red Rust-resistant Oats have numerous basal hairs, which are absent from grains of Other Red Oats.

Within these two groups of red oats there are a number of varieties, some of which we are now able to identify by seed characters. For example, Fulgrain and Fulghum, two varieties of the Other Red Oats group, are very similar in the field, but the seed of Fulgrain is lighter in color and slightly larger, broader, and plumper than that of Fulghum. The second floret of Fulgrain consistently separates from the first by breaking or tearing of the rachilla segment at the base of the first floret, as in Red Rust-resistant Oats. In Fulghum the second floret separates from the first by breaking at the base of the second floret, leaving the rachilla, with a smooth top, on the first floret. As a rule Fulghum seeds have more distinct lines than those of Fulgrain. Lastly, the basal scar on Fulgrain oats is more prominent than on Fulghum oats.

Wild Oats: All commercial varieties of oats came originally from two species of wild oats, *Avena fatua* and *Avena sterilis*. Seeds of the wild oats are often found in samples of commercial seed oats, and are classified as weeds. They are easily recognizable (Plate 4, figs. 1, 2). The seed scar, which is generally described as horse-shoe shaped or a suckermouth, is large and circular, surrounded by long stiff hairs. The rachilla, which is covered with these same hairs, widens at the apex into a triangle with rounded corners and has a marked central depression. The long, stiff awns are bent, and twisted as far as the bend. Wild oats found in samples of grain which have been cleaned usually have the awn broken off, but it leaves a conspicuous impression on both the lemma and the caryopsis.

The cultivated oat varieties often produce "off types" with characters resembling those of wild oats. These are classified as false wild oats (fatuoids) and heterozygous wild oats (Plate 4, figs. 3, 4). Any oat that has one or more characters of the wild oats is put into one of these classes. The false wild oat is "an aberrant grain type which occurs frequently in cultivated oats. Three theories have been advanced in explanation of the origin of fatuoids, namely, chromosome aberration, gene mutation and natural hybridization."[1] It is undesirable to have these "off

[1] Aamodt, O. S., L. P. V. Johnson, and J. Manson. *Can. Jour. Res.*, Vol. 2 (1934).

type'' oats in commercial seed, because they will produce throwbacks to the original wild oats.

As a result of our studies, we are now able to identify many of the varieties and to recognize most mixtures of seed oats. However, we realize that there is still much work to be done before we can confidently identify all varieties from the seed. It is our aim to continue these studies, in the hope that some day we shall be able to construct a key that can be used by all analysts in identifying oat varieties on the basis of seed characters.

NEW FLORIDA FUNGI

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The first stage in the study of fungi, as in other organisms, is taxonomic. There must be names and descriptions. Much work of this kind may appear to some to be valueless, but who can tell? A century or more ago only three species of *Penicillium* were recognized. In 1911 sixty had been described, among them *P. notatum,* source of the wonder drug, penicillin. We have in Florida a very common fleshy fungus known as *Lepiota Morgani.* It is poisonous, but might become the source of a drug similar to muscarin, which is used in hysteria. The destroying angel, *Amanita verna,* is common in our hammocks. Its very virulent poison might some day be used in fighting human diseases.

Some of the fleshy fungi cause diseases of trees. A very abundant and destructive root-rot is caused by *Clitocybe tabescens.* Woody fungi are well-known forest pests. The fleshy pore-fungi, or boletes, are mostly edible and few of ours are very dangerous. A common Florida species oxidizes to a beautiful blue color when cut. The climate of Florida is too warm and there are too many insects and molds to permit the profitable growing of mushrooms in the state, but great quantities of wild ones go to waste every year because of ignorance. The remedy for this is to have an expert inspect all collections before they are offered for sale.

The specimens recorded in the following pages are preserved in the herbarium of the Florida Agricultural Experiment Station at Gainesville. The nomenclature used is that of "North American Flora," but for the benefit of those following Saccardo a few of the names are changed at the end of the article to more familiar forms.

Armillaria australis sp. nov.

Pileo semigloboso-convexo, 1.5-2.5 cm lato, albo vel ochraceo, glabrato, grato; lamellis adnatis, integris, albis; sporis subellipsoideis, levibus, 4.5 × 3 μ; stipite aequali, concolore, squamuloso, 2 × 0.15-0.2 cm; annulo parvo, albo.

Pileus semiglobose to broadly convex, scattered, 1.5-2.5 cm broad: surface dry, white or ocher with minute floccose fibrils, becoming subglabrous, margin even, entire; context 1 mm thick, white, unchanging, odorless, mild; lamellae adnate with a small decurrent tooth, inserted, medium distant, 2-3 mm broad, entire, white; spores subellipsoid, smooth, hyaline, about 4.5 × 3 μ; cystidia none; stipe equal, white or cream,

glabrous at the apex, squamulose below, about 2 × 0.15-0.2 cm; annulus 1 cm from apex, small, white.

Type collected by W. A. Murrill on an open lawn in Gainesville, Fla., July 19, 1944 *(F 32708)*. Locally abundant. Many of the hymenophores turn buff on drying.

Armillaria caligata floridana var. nov.

Pileo 7-8 cm lato, grato, inodoro; lamellis adnexis vel adnatis, albis; sporis ovoideis vel ellipsoideis, 5 × 3 μ; stipite 5-7 × 1-3 cm.

Pileus convex to depressed, 7-8 cm broad; surface with bay or chestnut scales; context white, unchanging, odorless, mild; lamellae adnexed or adnate, rounded behind, 5 mm broad, close, entire, white, unchanged and rigid when dry; spores ovoid or ellipsoid, smooth, hyaline, about 5 × 3 μ; stipe subequal to obese, 5-7 × 1-3 cm, sheathed at first by the veil; annulus more or less ample, median, flaring, bay, often collapsing.

Type collected by W. A. Murrill under laurel oaks in Gainesville, Fla., Jan. 21, 1944 *(F 15948)*. Compared with specimens collected under oak in Michigan by A. H. Smith, who finds the spores as Kauffman described them, 6-7.5 × 5 μ. Bresadola gives 5-6 × 5 μ for the spores of his *forma gracilis*, collected under conifers. Kauffman perhaps confused *A. caligata* and *A. nardosmia* Ell., which latter species is frequent in Florida and is readily distinguished by its spores and fragile gills, which are dirty-brownish in herbarium specimens while those of *A. caligata* are rigid and white.

Cortinellus imbricatus felleus var. nov.

Non farinaceo sed praefelleo.

Resembling *Tricholoma imbricatum* (Fr.) in scaly surface and color but the context is decidedly bitter, though without odor. The spores are ovoid, smooth, hyaline, about 5-6 × 3-4 μ, some larger.

Type collected by W. A. Murrill on the ground in a pine grove at Gainesville, Fla., Jan. 10, 1938 *(F 15957)*. Rare in the vicinity. I at first referred it tentatively to *C. vaccinus* (Schaeff.) Roze, but soon decided it was not scaly enough for that species. Since the context is white it is nearer *C. imbricatus* than *C. flavobrunneus*.

Gymnopus omphalina sp. nov.

Pileo umbilicato, gregario, 1-1.3 cm lato, avellaneo, farinaceo, disco atro-avellaneo; lamellis adnatis, confertis, albis; sporis ovoideis, albis, levibus, 3 × 1.5 μ; stipite glabro, atro-avellaneo, 2 × 0.1-0.2 cm.

Pileus umbilicate, gregarious, 1-1.3 cm broad; surface dry, minutely fibrillose, avellaneous, the disk darker and cracked, margin incurved when young, even, entire, concolorous; context very thin, white, unchanging, with distinct farinaceous odor and taste; lamellae arcuate, squarely adnate, inserted, close, medium broad, very white and unchanging, entire; spores pipshaped, smooth, hyaline, about 3 × 1.5 μ; cystidia none; stipe subequal, more or less compressed, smooth, glabrous, dark-avellaneous, about 2 × 0.1-0.2. cm.

Type collected by W. A. Murrill on a grassy lawn partly shaded by frondose trees in Gainsville, Fla., Aug. 2, 1944 *(F 38952)*. Much like an omphalia but with gills squarely adnate.

Melanoleuca silvaticoides sp. nov.

Pileo convexo-expanso, gibboso, 4.5 cm lato, albo vel parte cremeo, viscido, glabro, farinaceo; lamellis sinuatis, confertis, albis; sporis ovoideis, levibus, 11 × 5-6 μ; stipite subaequali, albo, glabro, 4 × 0.8-1 cm.

Pileus convex to expanded, gibbous, solitary, 4.5 cm broad; surface white or partly cream, viscid, smooth, glabrous, shining, margin even, entire; context 2 mm thick, white, unchanging, taste at once farinaceous; lamellae sinuate, broad, ventricose, inserted, crowded, thin, white, unchanging, entire; spores ovoid, obliquely apiculate at base, smooth, hyaline, not amyloid, about 11 × 5-6 μ; cystidia none; stipe subequal, smooth, glabrous, hollow, not viscid, white, brownish when dry, 4 × 0.8-1 cm.

Type collected by W. A. Murrill in laurel-oak woods at Gainesville, Fla., Jan. 11, 1945 *(F 18508)*. Suggesting *M. silvatica* (Pk.) Murr., described from New York, but viscid. In *M. resplendens* (Fr.) Murr. the spores are only 7.5 × 4 μ.

Melanoleuca subcylindrispora sp. nov.

Pileo convexo-subdepresso, 5-6.5 cm lato, viscido, atrogriseo, grato; lamellis sinuatis, latis, albis; sporis levibus, 8 × 2.5-3 cm; stipite glabro, albo, 3 × 1.5 cm.

Pileus convex to somewhat depressed, gregarious, 5-6.5 cm broad; surface viscid, shining when dry, uniformly dark-griseous, margin even, entire, often becoming slightly upturned; context thin, whitish, unchanging, mild, with a faint pleasant odor; lamellae deeply sinuate-adnexed, broad, ventricose, crowded, inserted, entire, white; spores subcylindric, smooth, hyaline, not amyloid, about 8 × 2.5-3 cm; cystidia none; stipe subequal, stuffed, smooth, glabrous, shining, white, unchanging, about 3 × 1.5 cm.

Type collected by Dr. G. F. Weber in laurel-oak woods at Gainesville, Fla., Jan. 16, 1944 *(F 18649)*. Dr. Weber also collected a pale-avellaneous form *(F 19612)* at the same time and place, which was largely covered with sand. The only species I know that has slender spores like those described here is *M. lata* (Pk.) Murr., in which they measure 10-12 × 3.5-4 μ.

Melanoleuca subvolkertii sp. nov.

Pileo convexo-expanso, gibboso, 5 cm lato, glabro, avellaneo, praefarinaceo; lamellis sinuatis, latis, albis; sporis ovoideis, levibus, 6 × 4 μ; stipite solido, glabro, albo, 5-6 × 1.5 cm.

Pileus convex to expanded, gibbous, gregarious, about 5 cm broad; surface dry, glabrous, avellaneous, cuticle splitting radially, margin entire to slightly lobed; context thin, white, with strong farinaceous odor and taste; lamellae sinuate, broad, ventricose, rather crowded, entire, white, discolored brownish on drying; spores ovoid, smooth, hyaline, about 6 × 4 μ; cystidia none; stipe equal or tapering at both ends, solid, smooth, glabrous, white, unchanging, about 5-6 × 1.5 cm.

Type collected by W. A. Murrill in Columbia Co., Fla., under scrub oaks by the Santa Fe river northwest of High Springs, (Alachua Co.),

Dec. 14, 1941 *(F 15953)*. Suggesting *M. Volkertii* Murr., described from New York. It is also near *M. piperatiformis* Murr. and *M. australis* Murr., described from Florida.

Lepiota aurora sp. nov.

Pileo convexo-depresso, 3.5 cm lato, glabro, testaceo, disco latericio, grato; lamellis confertis, latis, albis, fimbriatis; sporis ovoideis, levibus, albis, 6 × 3 μ; stipite albo, glabro, bulboso, 1.5 × 0.5-0.8 cm; bulbo albo, 1 cm. lato; annulo parvo, albo.

Pileus convex to slightly depressed, gregarious, 3.5 cm broad; surface smooth, glabrous, testaceous with latericious center and paler margin, which is even, mostly entire, upturned with age; context thin, white, odorless, mild; lamellae free, inserted, close, broad, ventricose, white, unchanging, fimbriate; spores ovoid, smooth, white, about 6 × 3 μ; cystidia none; stipe enlarged downward, smooth, glabrous, white, unchanging, measuring about 1.5 × 0.5-0.8 cm above the large white ovoid bulb 1 cm thick; annulus basal, small, fixed, white, unchanging.

Type collected by W. A. Murrill in soil under shining privet in Gainesville, Fla., Aug. 12, 1944 *(F 22475)*. Very rare.

Lepiota brevipes sp. nov.

Pileo convexo-expanso, gibboso, 2-3 cm lato, badio, squamuloso, farinaceo; lamellis liberis, confertis, albis, fimbriatis; sporis ovoideis, levibus, albis, 5 × 3 μ; stipite squamuloso, concolore, 1.5 × 0.4-1 cm; annulo parvo, badio, evanido.

Pileus convex to expanded, gibbous, scattered, 2-3 cm broad; surface dry, bay, the cuticle cracked into scales except at the center, margin even, entire to lobed and split; context thin, white, unchanging, strongly farinaceous in odor and taste; lamellae free, inserted, ventricose, rounded behind, close, 4 mm broad, white, unchanging, fimbriate; spores ovoid, smooth, hyaline, about 5 × 3 μ; cystidia none; stipe enlarged downward, glabrous and rosy-avellaneous above, scaly and bay below, 1.5 × 0.4-1 cm; annulus small, median, bay, vanishing.

Type collected by W. A. Murrill on the ground in an open high hammock at Gainesville, Fla., Aug. 13, 1944 *(F 21631)*. Rare in the vicinity. Suggesting *L. cinnabarina* A. & S. but with a shorter stem and farinaceous odor and taste.

Lepiota fumosialba sp. nov.

Pileo convexo-plano, 2.5 cm lato, fumoso pallidoque, granuloso subsquamulosoque; lamellis confertis, albis; sporis ellipsoideis, levibus, albis, 4.5 × 3 μ; stipite aequali, albo, glabro, 3 × 0.2 cm; annulo parvo, albo.

Pileus convex to plane, gregarious, 2.5 cm broad; surface finely granulose to subsquamulose, fumosous to pallid, margin even to excoriate, entire to ragged; context thin, white, odorless; lamellae free, inserted, ventricose, medium broad, close, entire, white, discolored on drying; spores broadly ellipsoid, 1-sided, 1-guttulate, smooth, white, about 4.5 × 3 μ; cystidia none; stipe equal, smooth, white, glabrous, about 3 × 0.2 cm; annulus small, white, fixed 1 cm from apex, sometimes movable with age.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., July 5, 1944 *(F 32906)*. An average hymenophore of this species has a large smoke-colored disk and a broad whitish margin, while older caps may be entirely pallid, or fumose only at the center.

Lepiota fumosiceps sp. nov.

Pileo conico-convexo, umbonato, 1.5-2 cm lato, fibrilloso-squamuloso, murino ad fumoso, grato; lamellis latis, albis; sporis ellipsoideis, levibus, albis, 9 × 5.5 μ; stipite aequali, albo demum avellaneo, glabro, 2.5-3 × 0.1-0.15 cm; annulo amplo, albo.

Pileus conic to convex with umbo, not fully expanding, scattered or gregarious, 1.5-2 cm broad; surface finely fibrillose-squamulose, murinous when young, at maturity fumosous with murinous umbo, margin even, entire; context thin, white, unchanging, odorless, mild; lamellae free, inserted, rounded behind, broad, ventricose, close, entire, white, becoming reddish when bruised; spores ellipsoid, smooth, white, 1-guttulate, about 9 × 5.5 μ; cystidia none; stipe equal, smooth, glabrous, white and shining when young becoming avellaneous with age, 2.5-3 × 0.1-0.15 cm; annulus large, membranous, white, fixed 5 mm from apex, sometimes separating from the stem with age.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., July 5, 1944 *(F 32939)*. Occasional in the vicinity. Suggesting mycena when I first saw it.

Lepiota sanguiflua sp. nov.

Pileo depresso, umbonato, 11 cm lato, sulcato, atrosquamuloso, grato; lamellis liberis, albis, integris; sporis ellipsoideis, levibus, albis, 8 × 5-6 μ; stipite clavato, atrosquamuloso, fracto rubescenti, 8-10 × 1-1.5 cm; velo parvo, albo, evanido.

Pileus cylindric to expanded and depressed with broad umbo, cespitose, to 11 cm broad; surface dry, long-sulcate, white with fuliginous center and minute fibrillose tufted blackish scales thinning out toward the thin entire margin; context thin, white, unchanging, odorless, mild; lamellae free, rounded behind, ventricose, 8 mm broad, few inserted, medium close, white, unchanging, entire; spores ellipsoid, smooth, white, 1-guttulate, about 8 × 5-6 μ; cystidia none; stipe enlarged downward to a clavate base, smooth, glabrous and white at the apex, rosy-avellaneous and clothed like the pileus below, exuding a reddish juice when cut, reddish-brown when bruised, 8-10 × 1-1.5 cm; veil superior, small, white, vanishing early and leaving no annulus.

Type collected by W. A. Murrill in rich soil under a live-oak in Gainesville, Fla., Aug. 20, 1944 *(F 18289)*. Very rare. Herbarium specimens show a slow change from white to rose in surface of cap and gills.

Lepiota subasperula sp. nov.

Pileo plano, subumbonato, 5-6 cm lato, ochroleuco, disco isabellino, acutesquamoso, grato; lamellis liberis, confertis, angustibus, albis; sporis amygdaliformibus, levibus, albis, 6 × 2.5 μ; stipite albo, subbulboso, 5-7 × 0.7-1 cm; annulo supero, albo, parvo vel demum evanido.

Pileus fully expanding with a broad low umbo, gregarious, 5-6 cm broad; surface dry, ochroleucous, the disk isabelline, decorated all over with small erect pale-fulvous tufted scales, margin paler, even, entire; context thin, white, odor faintly pleasant, taste somewhat pungent; lamellae free, few inserted, very close and very narrow, white, unchanging, fimbriate; spores pipshaped, smooth, white, about 6 × 2.5 μ; cystidia none; stipe equal above a small bulb, white, unchanging, smooth at the apex, rough below, 5-7 × 0.7-1 cm; annulus 1 cm from top, white, collapsed, small or vanishing.

Type collected by W. A. Murrill in soil under shrubs at Gainesville, Fla., Aug. 22, 1944 *(F 19686)*. Suggesting *L. Friesii* (Lasch) in color and *L. asperula* Atk. in the small spores. This section is difficult and should be carefully worked in the field. Southern specimens are rare.

Lepiota Venus sp. nov.

Pileo convexo-expanso, gibboso, 2.5 cm lato, velutino, avellaneo, disco atro-fuligineo; lamellis liberis, latis, confertis, albis, fimbriatis; sporis ovoideis, levibus, albis, 6-7 × 4 μ; stipite bulboso, fuligineo, fibrilloso, 4 × 0.3-0.7 cm; annulo fuligineo.

Pileus convex to expanded with broad low umbo, solitary, 2.5 cm broad; surface velvety, avellaneous, dark-fuliginous at the center, margin even, entire; context rather thick, white, unchanging, with pleasant odor; lamellae free, rounded behind, ventricose, broad, close, very white, unchanging, fimbriate; spores ovoid, smooth, white, 6-7 × 4 μ; cystidia none; stipe enlarged downward to a small bulb, fuliginous, punctate-fibrillose, apex white, 4 × 0.3-0.7 cm; annulus median, rather large, fuliginous below, persistent.

Type collected by W. A. Murrill in leaf-mold under a laurel oak at Gainesville, Fla., Aug. 12, 1944 *(F 20045)*. In herbarium specimens the cap and stem are dark-fuliginous, while the gills have become old-rose with the beautifully fringed edges remaining white. Very rare.

Marasmius superabundans sp. nov.

Pileo convexo-expanso, gregario, 3-4 cm lato, glabro, isabellino vel fulvo, grato; lamellis adnexis, angustibus, pallidis, dentatis; sporis ovoideis, levibus, 7 × 4 μ; stipite aequali, pruinoso, subconcolore, 4-6 × 0.2-0.4 cm.

Pileus convex to subexpanded or plane, often umbonate, gregarious, 3-4 cm broad; surface dry, smooth, glabrous, isabelline or fulvous, frequently pallid at the center, margin even, entire, slightly striate with age; context membranous, white or discolored, odorless, mild; lamellae adnexed, narrow, usually close, pallid, minutely notched; spores pip-shaped, smooth, hyaline, about 7 × 4 μ; cystidia none; stipe equal or subequal, hollow, isabelline, white-pruinose when young, 4-6 × 0.2-0.4 cm.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., Aug. 11, 1944 *(F 32713)*. Very abundant on lawns in the vicinity during summer rains. Near *M. domesticus* Murr.

Monadelphus subilludens sp. nov.

Pileo convexo-subexpanso, caespitoso, 10-15 cm lato, glabro, ferrugineo vel latericio; lamellis decurrentibus, 7-15 mm latis, luteis demum latericiis;

sporis ovoideis, levibus, albis, 7-9 × 5 μ; stipite glabro, solido, luteo demum avellaneo, 3-6 × 1.5-2.5 cm.

Pileus convex to subexpanded, centrally depressed to infundibuliform, cespitose, up to 15 cm broad; surface glabrous, smooth or slightly rugose, ferruginous or latericious, margin even, undulate or lobed; context 1 cm thick, flavous, unchanging, with strong unpleasant odor and slightly astringent taste; lamellae long-decurrent, several times inserted, distant behind and crowded toward the margin, 7-15 mm broad, luteous to orange when young, latericious with age, entire; spores elongate, ovoid or ellipsoid, smooth, white, 1-2-guttulate, about 7-9 × 5 μ; cystidia none; stipe short, solid, subequal, often eccentric, firm, glabrous, marked with fine longitudinal lines, luteous, avellaneous with age, 3-6 × 1.5-2.5 cm.

Type collected by E. West on *Phoenix canariensis* at Gainesville, Fla., Apr. 21, 1944 *(F 19653)*. Cotype collected by W. A. Murrill, July 26, 1944 *(F 22197)*. Frequent in the vicinity on dead stumps and roots of oak, plum, palm, etc. Also found in Volusia Co., Fla. I have distributed it as *M. illudens*, which it closely resembles except in spore characters. *Pleurotus olearius* is different from both.

Monadelphus umbriniceps sp. nov.

Pileo convexo-subdepresso, gregario, vel caespitoso, 5-7 cm lato, glabro, umbrino, grato; lamellis adnatis, albis, integris; sporis ellipsoideis, 5-6 × 3-4 μ; stipite subbulboso, glabro, albo, 3-5 × 1-1.5 cm.

Pileus convex to slightly depressed, gregarious or cespitose, 5-7 cm broad; surface slightly viscid, smooth, glabrous, umbrinous, shining, margin even, entire to undulate or slightly lobed; context medium thick, white, unchanging, with pleasant odor and sweetish to slightly unpleasant taste; lamellae adnate, 5-7 mm broad, inserted, close, entire, white, discolored on drying; spores ellipsoid, smooth, hyaline, not amyloid, 5-6 × 3-4 μ; cystidia none; stipe equal above the enlarged base, solid, smooth, glabrous, white, unchanging, 3-5 × 1-1.5 cm.

Type collected by W. A. Murrill on an open grassy lawn near laurel oaks in Gainesville, Fla., Jan. 5, 1945 *(F 18021)*. Numerous hymenophores were found in a large fairy ring. The dried specimens suggest an entoloma. Related to *Clitocybe oreades* Murr.

Russula crataegorum sp. nov.

Pileo convexo-subexpanso, 9 cm lato, sicco, glabro, incarnato cremeoque, grato; lamellis adnatis, latis; sporis ellipsoideis, tuberculatis, flavidis, 8 × 6.5 μ; stipite aequali, glabro, albo parte roseo, 5 × 2 cm.

Pileus convex to subexpanded, solitary, 9 cm broad; surface dry, glabrous, incarnate and dark-cream, margin even, subentire, not peeling; context 5 mm thick, white, unchanging, odorless, mild; lamellae adnate, plane, 8 mm broad, medium distant, slightly fimbriate, inserted, cremeous with age; spores broadly ellipsoid, distinctly tuberculate, pale-yellow, amyloid, about 8 × 6.5 μ; cystidia none; stipe equal, smooth, glabrous, white with a rosy blush, 5 × 2 cm.

Type collected by W. A. Murrill under a hawthorn in a low moist spot in mixed woods near Gainesville, Fla., Oct. 1, 1944 *(F 12185)*. A large, attractive species, evidently very rare. Eaten by squirrels.

Russula pinophila sp. nov.

Pileo convexo-subdepresso, 5-6 cm lato, viscido, glabro, rubro vel parte cremeo, grato; lamellis adnatis, latis, albis; sporis subglobosis, echinulatis, albis, 8-11 × 7-9 μ; cystidiis abundantibus; stipite aequali, glabro, albo, 4 × 1.2 cm.

Pileus convex to slightly depressed, gregarious or scattered, 5-6 cm broad; surface viscid, smooth, glabrous, red or red and cream, margin even, entire; context firm, white, unchanging, odorless, mild; lamellae adnate, medium distant, broad, white, entire; spores white in mass, subglobose or ellipsoid, roughly echinulate, 8-11 × 7-9 μ; cystidia abundant on edges, bottle-shaped, about three times as long as the basidia; stipe equal, smooth, glabrous, white, unchanging, about 4 × 1.2 cm.

Type collected by W. A. Murrill on a grassy lawn under a longleaf pine at Gainesville, Fla., Jan. 9, 1945 *(F 17982)*. Frequent under longleaf pines in the vicinity in midwinter. A purple form found on Jan. 8, 1945, has the appearance of *R. subsericeonitens* Murr. but is distinct *(F 17799)*. The cystidia in *R. pinophila* are rather peculiar, strongly suggesting an ordinary four-ounce bottle.

Russula pusilliformis sp. nov.

Pileo convexo-subdepresso, 5 cm lato, glabro, rubro vel incarnato, striato, grato; lamellis adnatis, latis, albis: sporis ellipsoideis, echinulatis, ochroleucis, 8 × 6 μ; stipite glabro, albo, 5 × 1-1.3 cm.

Pileus convex to slightly depressed, scattered, about 5 cm broad; surface subviscid, glabrous, uniformly red or incarnate, margin striate, entire, peeling readily; context very thin, white, unchanging, odorless, mild; lamellae adnate, plane, several forked at base, few inserted, broad, close to medium distant, entire, white, soon yellow; spores ochroleucous in mass, ellipsoid, densely and distinctly echinulate, about 8 × 6 μ; cystidia none; stipe subequal, smooth, glabrous, white, unchanging, about 5 × 1-1.3 cm.

Type collected by W. A. Murrill in a high hammock at Gainesville, Fla., July 17, 1944 *(F 20110)*. Frequent in the vicinity under laurel oak from April to July. Suggesting *R. pusilla* of Beardslee and Coker, found under oaks in North Carolina, but larger than *R. pusilla* Pk., found under pines in New York.

Russula subbrunneipes sp. nov.

Pileo convexo-subdepresso, 5.5 cm lato, glabro, roseo, striato, grato; lamellis adnexis, confertis; sporis ellipsoideis, echinulatis, ochroleucis, 10 × 8 μ; stipite inaequali, glabro, subroseo, 8 × 1.3-1.8 cm.

Pileus convex to slightly depressed, solitary, 5.5 cm broad; surface slightly viscid, glabrous, uniformly roseous with a lilac tint, margin striate, entire, peeling readily; context very thin, white, unchanging, odorless, mild; lamellae adnexed, plane, narrowed behind, broad in front, not inserted, close, entire, soon flavous; spores broadly ellipsoid, strongly echinulate, ochroleucous, about 10 × 8 μ; cystidia none; stipe enlarged downward, hollow, smooth, glabrous, white with a rosy tint, 8 × 1.3-1.8 cm.

Type collected by W. A. Murrill in a high hammock at the Millhopper, near Gainesville, Fla., July 16, 1944 *(F 19149)*. A beautiful species, evidently rare.

Russula subsulphurea sp. nov.

Pileo convexo-subdepresso, 9-10 cm. lato, glabro, demum striato, grato; lamellis emarginatis, latis, albis; sporis ellipsoideis, subtuberculatis, albis, 8 × 6 μ; stipite glabro, albo, 4-6 × 1-5-2.5 cm.

Pileus convex to saucer-shaped, solitary, 9-10 cm broad; surface slightly viscid, glabrous, pallid with sulphureous and rosy-avellaneous tints, margin even to striate, entire to undulate or rimose, peeling readily; context thin, firm, white, unchanging, odorless, mild; lamellae emarginate, 1 cm broad, ventricose, rather close, firm, entire, white, unchanging; spores white, broadly ellipsoid, minutely tuberculate, about 8 × 6 μ; cystidia none; stipe tapering downward, solid, smooth, glabrous, white, unchanging, 4-6 × 1.5-2.5 cm.

Type collected by W. A. Murrill under laurel oak in Gainesville, Fla., June 20, 1944 *(F 18019)*. Also collected by the author in dry mixed woods near Gainesville on Oct. 1, 1944 *(F 18743)*. A large, rare species; eaten by squirrels.

Venenarius malodorus sp. nov.

Pileo convexo, 6-9 cm lato, roseo-isabellino, verrucis dense obtecto; lamellis adnexis, confertis, subroseis; sporis ellipsoideis, levibus, albis, 10 × 7 μ; stipite albo, solido, 10-12 × 1-2 cm; volva diffracta et evanida; annulo amplo, pallido, fimbriato.

Pileus convex, solitary, 6-9 cm broad; surface rosy-isabelline covered with small volval patches, margin even, entire; context thin, white, mild, with a strong musty odor which lasts for at least a year in dried specimens; lamellae adnexed, inserted, close, 8 mm broad, fragile, white with a slight pinkish tint; spores broadly ellipsoid, smooth, granular, white, about 10 × 7 μ; stipe equal or tapering downward, solid, cottony above, glabrate below, white without and within, slightly bulbous, 10-12 × 1-2 cm; volva entirely friable; annulus ample, thin, cottony beneath, fimbriate, pallid, skirtlike, superior.

Type collected by W. A. Murrill under a privet hedge in Gainesville, Fla., Aug. 11, 1944 *(F 32707)*. Unlike any other species in the genus, with an odor that has not yet been described.

Venenarius subcitriniceps sp. nov.

Pileo convexo-depresso, 4 cm lato, glabro, subcitrino; lamellis adnatis, confertis, angustatis, albis; sporis ellipsoideis, 6-8 × 4-5 μ; stipite floccoso, albo, 8 × 0.6-1 cm; bulbo albo, 2 × 1.3 cm, volva evanida; annulo albo, parvo.

Pileus convex to saucer-shaped, solitary, 4 cm broad; surface slightly viscid when wet, smooth, glabrous, uniformly pale-citrinous, margin even, entire; context very thin, white, unchanging, odorless; lamellae adnate with a slight decurrent tooth, very close, narrow, few inserted, white, unchanging, finely fimbriate; spores subellipsoid, smooth, 1-guttulate, about 6-8 × 4-5 μ; stipe slightly enlarged downward, white, unchanging, floccose above and below the ring, about 8 × 0.6-1 cm; bulb only slightly enlarged, white, 2 × 1.3 cm, volva limb friable at an early stage; annulus small, white, persistent, collapsing, fixed about 2 cm from apex.

Type collected by W. A. Murrill under a laurel oak at Gainesville, Fla., June 30, 1944 *(F 38901)*. Very rare; and distinguished at once by its color.

Venenarius subphalloides sp. nov.

Pileo convexo-expanso, 4 cm lato, viscido, umbrino, disco fuligineo; lamellis confertis, albis; sporis globosis, 6-8 μ; bulbo parvo, globoso, albo, volva evanida; annulo amplo, albo.

Pileus convex to slightly depressed, solitary, 4 cm broad; surface viscid, with a few volval patches, umbrinous with fuliginous disk, margin at times very slightly striate with age, entire; context thin, white, odorless; lamellae very close, slightly decurrent, white with a rosy tint, narrow; spores globose, smooth, hyaline, granular, 6-8 μ; stipe subequal, white, blushing below where bruised, 6 $\times$ 0.5-0.7 cm; annulus large, white, skirt-like, fixed 1-2 cm from apex; bulb globose, small, white, volva limb mostly carried up as fragments on cap.

Type collected by Lillian Arnold under a laurel oak in Gainesville, Fla., July 11, 1938 *(F 17832)*. Frequent in the vicinity in moist frondose woods during midsummer. Suggesting *V. fraternus* Murr. but with different spores. Possibly the same as Coker's depauperate form of *V. phalloides*. Some may prefer to consider it only a variety, but I think it is so very distinct and easily recognized that it may as well be accorded specific rank now and save some young mycologist the trouble a decade or two hence.

Venenarius subrecutitus sp. nov.

Pileo convexo-depresso, 5-7 cm lato, avellaneo, viscido, grato, striato; lamellis latis, albis; sporis ellipsoideis, 8-9 $\times$ 5-6 μ; stipite aequali, albo, 6 $\times$ 0.6-0.8 cm; volva vaginata, alba, parte evanida; annulo parvo, albo, medio.

Pileus convex to depressed, scattered, 5-7 cm broad; surface avellaneous, viscid, with a few volval patches, margin striate, entire; context thin, white, odorless, mild; lamellae broad, ventricose, rather close, white, entire; spores ellipsoid, smooth, hyaline, granular, about 8-9 $\times$ 5-6 μ; stipe equal, smooth, white, about 6 $\times$ 0.6-0.8 cm; volva sheathing, white, partly carried up as fragments on the cap; annulus median, small, white, fixed.

Type collected by W. A. Murrill on the open margin of a flatwoods pond east of Gainesville, Fla., Mar. 26, 1944 *(F 17996)*. Collected several times by the author in the vicinity. Suggesting *V. spretus* and *V. recutitus* but distinct from both.

Venenarius verniformis sp. nov.

Pileo convexo-plano, 7 cm lato, albo, glabro; lamellis confertis, albis; sporis ellipsoideis, albis, 10 $\times$ 6 μ; stipite albo, bulboso, 8 $\times$ 1 cm; volva alba, semilibera, ampla; annulo amplo, albo, apicali.

Pileus convex to plane, solitary, 7 cm broad; surface slightly viscid, smooth, glabrous, milk-white, margin even, entire; context thin, white, unchanging, odorless; lamellae just touching, close, narrow, inserted, white, fimbriate; spores ellipsoid, smooth, white, about 10 $\times$ 6 μ; stipe subequal

above the bulb, smooth, white, unchanging, glabrous, 8 × 1 cm; bulb large, ovoid, white, volva ample, white; annulus ample, white, fixed 1 cm from apex.

Type collected by W. A. Murrill under a live-oak near Newnan's Lake, Alachua Co., Fla., July 9, 1944 *(F 32931)*. Strongly resembling *V. vernus* but with ellipsoid spores. Dr. Coker mentioned a plant like this found in North Carolina, but considered it only a form of *V. vernus*. Our Florida *V. vernus* has globose spores similar to those figured for the species by Bresadola.

Gymnopilus praelaeticolor sp. nov.

Pileo convexo, caespitoso, 6-8 cm lato, flavo, squamuloso, farinaceo; lamellis adnatis, confertis, luteis, dentatis; sporis ellipsoideis, levibus, 7 × 5 μ; stipite pallido, fibrilloso, 5-7 × 1-1.8 cm.

Pileus convex, not fully expanding, cespitose, 6-8 cm broad; surface dry, flavous, squamulose, with tufts of erect or recurved fibrils, margin even, entire to undulate; context 0-5 mm or more thick, cremeous, fragrant, slightly astringent and farinaceous; lamellae adnate, emarginate with age, inserted, at first plane, becoming broader behind, very close at margin, luteous, conspicuously notched with age, orange from the spores, which are ellipsoid, smooth, 1-guttulate, bright-yellow, about 7 × 5 μ; cystidia none; stipe subequal, solid, pallid, cremeous within, fibrillose, streaked and ridged, 5-7 × 1-1.8 cm.

Type collected by W. A. Murrill on a stump of laurel oak in Gainesville, Fla., June 17, 1944 *(F 38861)*. A striking species, not at all common.

Hebeloma pallidifolium sp. nov.

Pileo conico-expanso, gregario, 3 cm lato, lucido, roseo-isabellino, farinaceo; lamellis sinuatis, pallidis, fimbriatis; sporis ovoideis, levibus, 10-11 × 5-6 μ; stipite albo, glabro, 2.5 × 1 cm.

Pileus conic to plane, gregarious, about 3 cm broad; surface shining, pale-rosy-isabelline, margin radiately striate owing to the split cuticle; context thin, white, with very farinaceous odor and taste; lamellae sinuate, ventricose, rather close and narrow, unusually pale, beautifully white-fimbriate; spores elongate-ovoid, inequilateral, pale-yellowish-brown, smooth, 1-guttulate, 10-11 × 5-6 μ; stipe enlarged above and below, white, smooth, glabrous, shining, about 2.5 × 1 cm.

Type collected by W. A. Murrill in an open high hammock at Worthington Springs, Union Co., Fla., Nov. 19, 1944 *(F 19517)*. Well characterized by its split cuticle and unusually pale gills, even after drying.

Hebeloma praefelleum sp. nov.

Pileo convexo-subplano, gregario, 5 cm lato, glabro, albido, praefelleo; lamellis sinuatis, confertis, integris, pallidis; sporis ellipsoideis, levibus, 10-11 × 5-6 μ; stipite albo, glabro, 2.5 × 1 cm.

Pileus convex to nearly plane, gregarious, reaching 5 cm broad; surface smooth, glabrous, dull-white, shining when dry, margin even, entire to undulate; context thin, white, unchanging, odor strong, taste very bitter at once; lamellae sinuate, crowded, inserted, narrow, entire, pallid, soon yellowish-brown; spores ellipsoid, smooth, 1-guttulate, pale-yellowish-

brown, about 8 × 4 μ; stipe equal above the swollen base, smooth, glabrous, white, unchanging, about 4 × 1.2-1.5 cm.

Type collected by W. A. Murrill on a lawn under laurel oaks in Gainesville, Fla., Jan. 11, 1945 *(F 17505)*. Suggesting *H. pallidifolium* Murr. and *Cortinaria lacticeps* Murr. but plainly different from either.

Inocybe cylindrispora sp. nov.

Pileo convexo-plano, gregario, 2.5-3.5 cm lato; umbrino, grato, margine rimoso isabellinoque; lamellis sinuatis, latis, fimbriatis; sporis levibus, 10-12 × 3-4 μ; stipite aequali, glabro, pallido, 3 × 0.3-0.4 cm.

Pileus convex to plane, often umbonate, gregarious, 2.5-3.5 cm broad; surface isabelline or umbrinous, fibrillose, becoming rimose and isabelline on the broad, entire margin; context very thin, pallid, mild, with a slight farinaceous odor; lamellae sinuate, close, broad, fimbriate; spores cylindric, smooth, pale, 10-12 × 3-4 μ; cystidia conic, 30 × 13 μ; stipe equal, smooth, glabrous, pallid or pale-rosy-isabelline, about 3 × 0.3-0.4 cm.

Type collected by W. A. Murrill on a lawn under a longleaf pine in Gainesville, Fla., Dec. 30, 1944 *(F 19235)*. Characterized by its slender spores. On Jan. 19, 1945, a pale form *(F 20328)* was found by the author under longleaf pine. Most of the caps were umbonate; the gills and stems were almost white; and the cystidia were conic, truncate, muricellate, hyaline, about 30 μ high and 15 μ thick at the base, found on the edges of the gills.

Inocybe floridana sp. nov.

Pileo convexo-expanso, 3 cm lato, pallido, subsquamuloso; lamellis sinuatis, confertis, pallidis; sporis angulatis, praepallidis, 9 × 5 μ; cystidiis ventricosis, muricellatis, 30 × 12 μ; stipite bulboso, pruinoso, pallido, 5.5 × 0.7 cm.

Pileus convex to expanded, solitary, 3 cm broad; surface white or pallid, minutely scaly except on the smooth milk-white disk, margin even, entire, rimose with age; context very thin, white, unchanging; lamellae sinuate, inserted, medium broad, close, entire, pallid, white-fimbriate; spores ellipsoid in outline, somewhat angular, 1-guttulate, very pale, about 9 × 5 μ; cystidia abundant, ventricose, muricellate, hyaline, projecting about 30 × 12 μ; stipe equal above the abruptly bulbous base, pruinose, especially above, grooved, pallid with a slight rosy-isabelline tint, about 5.5 × 0.7 cm.

Type collected by W. A. Murrill on a shaded lawn in Gainesville, Fla., Oct. 25, 1938 *(F 19961)*. Also collected by the author in a nearby high hammock, Sept. 21, 1938. A rare white species distinguished from *I. hebelomoides* Murr. by its angular spores.

Inocybe fulvelliceps sp. nov.

Pileo convexo-expanso, umbonato, 1.2 cm lato, fulvo, subglabro; lamellis confertis, adnatis, pallidis; sporis angulatis, tuberculatis, 8 × 6 μ; cystidiis muricellatis; stipite bulboso, albo, 2 × 0.3 cm.

Pileus hat-shaped at maturity with prominent umbo, solitary, 1.2 cm broad; surface dry, minutely squamulose, pale-fulvous, margin even, entire, isabelline; lamellae narrowly adnate, close, medium broad, in-

serted, pallid, slightly fimbriate; spores angular-tuberculate, about 8 × 6 μ; cystidia slender, flask-shaped, muricellate, abundant; stipe tapering upward above the nonmarginate bulb, white, smooth, 2 × 0.3 cm.

Type collected by W. A Murrill on a lawn under an oak at Gainesville, Fla., May 9, 1938 *(F 8950)*.

Inocybe fulviceps sp. nov.

Pileo convexo-subexpanso, umbonato, gregario, 2 cm lato, fulvo, fibrilloso-squamuloso; lamellis sinuatis, latis; sporis subellipsoideis, levibus, ferrugineis, 10-12 × 5-6 μ; stipite aequali, pallido, subglabro, 3 × 0.2 cm.

Pileus convex to subexpanded with small pointed umbo, gregarious, about 2 cm broad; surface very fibrillose-scaly, fulvous, paler on the disk, margin even, entire; context very thin; lamellae sinuate, rather distant, broad, pallid; spores elongate-subellipsoid, inequilateral, 1-guttulate, smooth, bright-ferruginous, 10-12 × 5-6 μ; cystidia none; stipe equal, pallid, subglabrous, about 3 × 0.2 cm.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., Aug. 11, 1944 *(F 18506)*.

Inocybe fulvi-umbonata sp. nov.

Pileo convexo-subexpanso, umbonato, gregario, 1.5 cm lato, tomentoso, isabellino, disco fulvo; lamellis adnatis, latis, fimbriatis; sporis subellipsoideis, pallidis, levibus, 7-8 × 4-5 μ; stipite aequali, isabellino, fibrilloso, 3 × 0.2-0.3 cm.

Pileus convex to subexpanded with a small but prominent umbo, gregarious, about 1.5 cm broad; surface tomentose, isabelline with fulvous umbo, margin even, entire; context very thin, pallid; lamellae plane, adnate, inserted, pallid, fimbriate, broad, medium distant; spores subellipsoid, inequilateral, smooth, very pale, rarely 1-guttulate, 7-8 × 4-5 μ; cystidia none; stipe equal, isabelline, fibrillose, about 3 × 0.2-0.3 cm.

Type collected by W. A. Murrill under laurel oak in Gainesville, Fla., July 8, 1944 *(F 24503)*. The pretty umbo is more prominent in dried specimens.

Inocybe gigantispora sp. nov.

Pileo convexo-expanso, umbonato, 2.5-3.5 cm lato, squamoso fibrillosoque, umbrino-fulvo, grato; lamellis sinuatis, latis, pallidis; sporis levibus, 13-16 × 5-6 μ; cystidiis nullis; stipite aequali, fibrilloso, concolore, 3-4 × 0.3-0.5 cm.

Pileus convex to expanded with a prominent mammillate umbo, gregarious, 2.5-3.5 cm broad; surface dry, umbrinous-fulvous, densely imbricate-scaly, margin fibrillose, paler, deflexed when young, slightly undulate and ragged when old; context very thin, white, unchanging, odorless, mild; lamellae sinuate, inserted, broad, medium close, rounded behind, entire, pallid to dirty-pallid; spores amygdaloid with rounded ends, smooth, uniguttulate, very pale yellowish-brown, about 13-16 × 5-6 μ; cystidia none; stipe equal, solid, streaked, fibrillose, pallid at apex, concolorous below, 3-4 × 0.3-0.5 cm.

Type collected by G. F. Weber in open moist ground between live-oaks and a flatwoods pond east of Gainesville, Fla., Jan. 23, 1944 *(F 20061)*.

Also collected by the author nearby in a similar habitat on the same day *(F 19584)*. In the same group with Atkinson's *I. marmoripes* and *I. subrubescens*, with spores as large as those of the latter species but not reniform. The color of the spores is unusually pale for the genus and the single gutta is very prominent.

Inocybe hebelomoides sp. nov.

Pileo convexo-expanso, umbonato, 3.5 cm lato, viscido, stramineo; sporis ovoideis, 8 × 5 μ, cystidiis 40 × 15 μ; stipite albo, 5 × 0.5-0.6 cm.

Pileus convex to expanded, umbonate, gregarious, 3.5 cm broad; surface viscid, smooth, shining, glabrous, stramineous, margin even, entire; context white, unchanging, without characteristic odor or taste; lamellae adnexed with decurrent tooth, ventricose, medium broad and medium distant, inserted, pallid to discolored, edges fimbriate; spores ovoid, smooth, ferruginous, 1-guttulate, about 8 × 5 μ; cystidia bottle-shaped, hyaline, blunt and crested at the tip, projecting about 40 × 15 μ; stipe equal, smooth, shining, glabrous, white, furfuraceous at the apex, 5 × 0.5-0.6 cm.

Type collected by W. A. Murrill under hardwoods in a high hammock at Gainesville, Fla., Oct. 17, 1938 *(F 18365)*. Having the usual appearance of *Hebeloma* with cystidia like those of *Inocybe* and spores resembling those of *Cortinarius*. They are umbrinous in mass and ferruginous under the microscope.

Inocybe nucleata sp. nov.

Pileo conico-subexpanso, umbonato, 1.5 cm lato, umbrino, innato-fibrilloso; lamellis adnexis, latis; sporis angulatis, 7-9 × 5-6 μ; cystidiis ventricosis, muricellatis; stipite subbrunneo, pulverulento, 1.5 × 0.2 cm.

Pileus conic to subexpanded with mammillate umbo, solitary, 1.5 cm broad; surface uniformly umbrinous, shining, innate-appressed-fibrillose, slightly squamulose at the center, margin slightly undulate; context thin, pallid, odorless; lamellae adnexed, broad, ventricose, rounded behind, rather close, inserted, pallid, slightly uneven on the edge; spores very irregularly angular with one very large gutta, oblong, pale, about 7-9 × 5-6 μ; cystidia ventricose below a cylindric neck, crested, projecting about 30 μ and 15 μ thick; stipe equal, finely striate, pale-brownish, whitish-pulverulent, especially above, 1.5 × 0.2 cm.

Type collected by W. A. Murrill in wet black soil in mixed woods by a pond southwest of Gainesville, Fla., May 14, 1944 *(F 32913)*. Characterized by its peculiar angular spores containing a very large nucleus.

Inocybe parvispora sp. nov.

Pileo convexo-subexpanso, umbonato, gregario, 2.5 cm lato, fibrilloso, isabellino, excoriato, disco umbrino, grato; lamellis adnatis vel emarginatis, confertis, fimbriatis; sporis subellipsoideis, pallidis, levibus, 5 × 3 μ; cystidiis muricellatis; stipite aequali, fibrilloso, albido, 3 × 0.3-0.4 cm.

Pileus convex to subexpanded with prominent conic umbo, gregarious, about 2.5 cm broad; surface dry, fibrillose, isabelline, disk dull-umbrinous, margin entire, excoriate; context thin, pallid, unchanging, odorless, mild; lamellae adnate or emarginate, plane, inserted, close, medium broad,

beautifully white-fimbriate; spores subellipsoid, inequilateral, smooth, pale, about 5 × 3 μ; cystidia few, flask-shaped, muricellate; stipe equal, fibrillose, like asbestos, about 3 × 0.3-0.4 cm.

Type collected by W. A. Murrill in short grass under a laurel oak at Gainesville, Fla., July 8, 1944 *(F 18674)*. Rare in the vicinity under laurel oak during July.

Inocybe pertomentosa sp. nov.

Pileo convexo-subexpanso, 1.5-2.5 cm lato, tomentoso, fulvo vel isabellino, grato; lamellis adnatis, latis, fimbriatis; sporis subellipsoideis, levibus, 10-12 × 5-6 μ; stipite tomentoso, isabellino, 2.5-3 × 0.15-0.2 cm.

Pileus convex to subplane, gregarious or cespitose, 1.5-2.5 cm broad; surface very tomentose, dark-isabelline or dark-fulvous, margin even, entire; context very thin, pallid, odorless, mild; lamellae emarginate or adnate, medium close, inserted, plane, broad, white-fimbriate; spores pale-yellowish-brown, umbrinous in mass, subellipsoid, inequilateral, 1-guttulate, smooth, 10-12 × 5-6 μ; cystidia none; stipe tapering downward, pale-yellowish-brown, tomentose, 2.5-3 × 0.15-0.2 cm.

Type collected by W. A. Murrill in moist shaded soil at Gainesville, Fla., July 18, 1944 *(F 19657)*. Also collected by the author in a thin high hammock in the vicinity on July 20, 1944 *(F 19693)*.

Inocybe praenucleata sp. nov.

Pileo convexo-expanso, umbonato, gregario, 2-3 cm lato, isabellino, innato-fibrilloso, demum radiato-rimoso, grato; lamellis sinuatis, 7 mm. latis, pallidis; sporis ovoideis, levibus, umbrinis, 8 × 5-6 μ; stipite aequali, solido, albo, 2-2.5 × 0.3-0.4 cm.

Pileus convex to expanded, umbonate, gregarious to subcespitose, 2-3 cm broad; surface dry, innate-fibrillose, becoming radiate-rimose, isabelline, margin concolorous, with short projecting fibers, the rounded umbo also concolorous; context thin, white, unchanging, mild, with farinaceous odor; lamellae sinuate, rounded behind, close to subdistant, 7 mm. broad, inserted, minutely notched, pallid to dirty-brownish; spores ovoid, smooth, 1-guttulate, umbrinous, about 8 × 5-6 μ; cystidia none; stipe equal, solid, white, minutely longitudinally furrowed, atomaceous above, 2-2.5 × 0.3-0.4 cm.

Type collected by W. A. Murrill under a longleaf pine on a lawn in Gainesville, Fla., Jan. 23, 1945 *(F 22501)*. The spores are unusually short and thick for the genus, with a very large nucleus.

Inocybe roseifolia sp. nov.

Pileo convexo-plano, 2.5 cm lato, isabellino, fibrilloso, grato; lamellis adnexis, roseis, fimbriatis; sporis ellipsoideis, levibus, 10 × 5 μ; cystidiis 30-40 × 10-15 μ; stipite aequali, fibrilloso, roseo alboque, 2.5 × 0.5 cm.

Pileus convex to plane, solitary, 2.5 cm broad; surface dry, isabelline, appressed-fibrillose, margin even, entire to slightly undulate or cracked; context very thin, white, unchanging, odorless, mild; lamellae adnexed or emarginate, plane, medium close, 3-4 mm broad, inserted, roseous throughout, edges blunt, finely fimbriate; spores ellipsoid, smooth, 1-guttulate, deep-ochraceous, about 10 × 5 μ; cystidia bottle-shaped, about

30-40 × 10-15 μ; sterile cells often like Indian clubs, abundant; stipe equal, not bulbous, fibrillose, pinkish above, white below, 2.5 × 0.5 cm.

Type collected by W. A. Murrill on bare ground under a laurel oak in Gainesville, Fla., June 20, 1944 *(F 38794)*. Peck described a species with violet gills and Bresadola figures *I. incarnata* Bres. and *I. Trinii* Weinm. with red-edged gills but I know of no species hitherto described in which the entire gill is pink. The cystidia, also, of my species are peculiar in having a solid ring at the apex like a milk-bottle, while many of the sterile cells on the edges of the gills are tipped with rounded knobs as in Indian clubs. These knobs are smaller and rounder than those of *I. fuscidula* Bres. Unfortunately, this interesting species is extremely rare.

Inocybe striatiformis sp. nov.

Pileo convexo-subexpanso, gregario, 1.5-2 cm lato, fuligineo, fibrilloso, rimoso; lamellis adnatis, latis, distantibus, pallidis; sporis subellipsoideis, levibus, pallidis, 12-15 × 5-7 μ; cystidiis nullis; stipite floccoso, roseo-isabellino, 1.5 × 0.3-0.5 cm.

Pileus convex to subexpanded, closely gregarious, 1.5-2 cm broad; surface dry, uniformly fuliginous, with stiff upturned fibrils, the cuticle split to the disk at maturity, margin deflexed on drying; context very thin, white, unchanging, odorless; lamellae adnate, inserted, distant, broad, pallid to isabelline with white edges; spores subellipsoid, smooth, 1-guttulate, very pale, 12-15 × 5-7 μ; cystidia none; stipe enlarged downward, floccose, pale rosy-isabelline, 1.5 × 0.3-0.5 cm.

Type collected by W. A. Murrill in sandy soil in an open high hammock at Gainesville, Fla., Aug. 16, 1944 *(F 20333)*. Suggesting *I. striata* Bres. in shape but much smaller, without umbo, and very different microscopically.

Inocybe subconnexa sp. nov.

Pileo convexo-subdepresso, 3-3.5 cm lato, fibrilloso, isabellino; lamellis sinuatis, latis, pallidis; sporis subovoideis, 11 × 5.5 μ; cystidiis ventricosis, apiculatis, 70 × 15 μ; stipite bulboso, albo, subglabro, 2.5 × 0.7 cm.

Pileus convex to slightly depressed, gregarious, 3-3.5 cm broad; surface dry, smooth, fibrillose, minutely scaly on the disk, uniformly isabelline, margin even, entire; context thin, white; lamellae sinuate, inserted, broad, ventricose, close, pallid to isabelline, white-fimbriate; spores subovoid, smooth, 1-guttulate, obliquely apiculate at the base, bright-ochraceous under the microscope, about 11 × 5.5 μ; cystidia ventricose with dark tip, not muricellate, about 70 × 15 μ; stipe equal above the rounded base, pruinose at the apex, white, subglabrous, about 2.5 × 0.7 cm.

Type collected by W. A. Murrill on a lawn in Gainesville, Fla., Mar. 28, 1944 *(F 19336)*. Suggesting *I. connexa*, described by Kauffman from Mass., but differing in several particulars.

Inocybe subfulviformis sp. nov.

Pileo conico-expanso, umbonato, 3-3.5 cm lato, fulvo, innato-fibrilloso, grato; lamellis emarginatis, distantibus; sporis globosis, prae-echinulatis, 10 μ; cystidiis clavatis, obtusis; stipite aequali, pallido, 3-4 × 0.2-0.3 cm.

Pileus conic to expanded with mammillate umbo, gregarious to sub-

cespitose, 3-3.5 cm broad; surface uniformly fulvous, innately appressed-fibrillose, squamulose at the center, margin splitting with age; context very thin and fragile, pallid, odorless, mild; lamellae emarginate, rather broadly attached, inserted, subventricose, 5 mm broad behind, distant, entire, pallid to brownish with whitish edges; spores globose, very spiny, about 10 μ; sterile cells few, clavate, obtuse, slightly larger than the basidia; stipe equal, hollow, pallid, whitish-pulverulent above, glabrescent below, whitish-mycelioid at the slightly enlarged base, 3-4 $\times$ 0.2-0.3 cm.

Type collected by W. A. Murrill in wet black soil in low mixed woods by a pond southwest of Gainesville, Fla., May 14, 1944 *(F 32955)*. Suggesting *I. subfulva* Pk. but much larger, with distant gills and a very different habitat.

Inocybe subradiata sp. nov.

Pileo conico-subexpanso, umbonato, 1.5 cm lato, castaneo, rimoso, fibrilloso; lamellis adnatis, confertis, fimbriatis; sporis angulatis, pallidis, 8 $\times$ 5 μ; cystidiis ventricosis, 70 $\times$ 15 μ; stipite roseo-isabellino, 5 $\times$ 0.15 cm.

Pileus conic to subexpanded and umbonate, solitary, 1.5 cm broad; surface castaneous, dry, finely appressed-fibrillose except on the disk, cuticle soon splitting into narrow radiating segments, margin thin, entire; context thin, white, unchanging; lamellae adnate, close, narrow, inserted, pallid, white-fringed; spores ellipsoid in outline, distinctly irregularly angular, very pale yellowish-brown, 1-guttulate, about 8 $\times$ 5 μ; cystidia large, ventricose, crested, about 70 $\times$ 15 μ; stipe equal above the small bulb, rosy-isabelline, pulverulent to partly subglabrous, 5 $\times$ 0.15 cm.

Type collected by W. A. Murrill in leaf-mold under a magnolia at Gainesville, Fla., Apr. 26, 1944 *(F 18570)*. Characterized by its chestnut-colored, radiate-rimose surface and prominent, ventricose cystidia.

Inocybe vialis sp. nov.

Pileo conico-campanulato, umbonato, gregario, 1.5 cm lato, atro-isabellino, tomentoso, grato; lamellis adnexis, latis, fimbriatis; sporis ellipsoideis, levibus, 10-12 $\times$ 5-6 μ; stipite aequali, albido, floccoso, 2 $\times$ 0.2 cm.

Pileus conic to campanulate and at length hat-shaped with a prominent conic umbo, gregarious, about 1.5 cm broad; surface dark-isabelline and shaggy with upturned tomentose scales, margin even, entire; context thin, odorless, mild; lamellae adnexed, broad, ventricose, inserted, medium distant, fimbriate; spores elongate-ellipsoid, smooth, pale, 1-guttulate, 10-12 $\times$ 5-6 μ; cystidia none; stipe equal, pallid, fibrillose-floccose, about 2 $\times$ 0.2 cm.

Type collected by W. A. Murrill in a path shaded by frondose trees at Gainesville, Fla., Sept. 20, 1944 *(F 20017)*. Suggesting *I. unicolor* Pk. but umbonate and having a more slender stem.

Naucoria floridana sp. nov.

Pileo convexo-subexpanso, gregario, 3-4 cm lato, glabro, isabellino ad fulvo, grato; lamellis adnatis, latis; sporis ovoideis, levibus, 9 $\times$ 4.5 μ; stipite subconcolore, fibrilloso, 3 $\times$ 0.3-0.5 cm.

Pileus convex to subexpanded, slightly umbonate at times, gregarious, 3-4 cm broad; surface smooth, dull, innate-fibrillose to glabrous, dark-isabelline to fulvous, margin even, entire; context thin, odorless, mild; lamellae adnate, close, broad, entire, soon fulvous; spores pip-shaped, 1-guttulate, smooth, pale-ferruginous under the microscope, about 9 × 4.5 μ; cystidia none; stipe equal, fibrillose, pallid or pale-ferruginous, about 3 × 0.3-0.5 cm.

Type collected by W. A. Murrill in sandy soil among low evergreen shrubs in flatwoods just east of Gainesville, Fla., Mar. 26, 1944 *(F 22502)*. Having the form of *Flammula carbonaria* but quite distinct.

Naucoria similiformis sp. nov.

Pileo convexo-depresso, gregario, 2-3 cm lato, viscido, glabro, ferrugineo-isabellino, grato; lamellis adnatis, praelatis, pallidis; sporis ovoideis, levibus, 7-8 × 4-6 μ; stipite pallido, glabro vel squamoso, 2-3 × 0.2-0.5 cm.

Pileus convex to depressed, gregarious or scattered, 2-3 cm broad; surface shining, slightly viscid when moist, glabrous, ferruginous-isabelline, smooth, the cuticle at length breaking into small fragments, margin fertile, even, entire, cream when young, often becoming sordid in a distinct zone, upturned in age; context thick, white, unchanging, odorless, mild; lamellae adnate, inserted, very broad, medium close, entire, pallid to brown; spores usually ovoid, smooth, mostly 1-guttulate, dark-ferruginous under the microscope, about 7-8 × 4-6 μ; cystidia none; stipe equal or slightly enlarged above and below, stuffed, pallid, smooth and glabrous above, usually scaly below, 2-3 × 0.2-0.5 cm.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., April 1, 1944 *(F 18240)*. The color of dried specimens suggests *N. similis* Bres., described from China.

Naucoria subsiparioides sp. nov.

Pileo convexo-expanso, 3-4 cm lato, ferrugineo, fibrilloso-verrucoso; lamellis adnatis, integris, subconfertis; sporis ellipsoideis, levibus, ferrugineis, 7-8 × 4-5 μ; stipite fulvo, pubescenti, 3 × 0.15-0.2 cm.

Pileus convex to expanded, scattered, 3-4 cm broad; surface uniformly ferruginous, closely covered with erect tufts of fibrils, margin inflexed at first, concolorous, even, entire to rimose; context very thin, pallid, unchanging, odorless, mild; lamellae squarely adnate, inserted, medium distant and medium broad, entire, soon dark-fulvous; spores ellipsoid, smooth, 1-guttulate, bright-ferruginous under the microscope, 7-8 × 4-5 μ; cystidia none; stipe cartilaginous, equal, yellowish-pubescent, dark-fulvous when fresh, darker when dried, about 3 × 0.15-0.2 cm.

Type collected by G. F. Weber attached to vegetable débris in a dried-up cypress swamp in Cary Forest, east of Gainesville, Fla., Jan. 18, 1944 *(F 18091)*. Related to *N. siparioides* (B. & C.) Sacc., found in the mud of a dry swamp in New England.

Agaricus alligator sp. nov.

Pileo convexo-expanso, 6-10 cm lato, albo, squamoso, grato; lamellis confertis, pallidis; sporis ellipsoideis, 5-6 × 4 μ; stipite aequali, solido, glabro, albo, 7 × 1.7 cm; amplo, albo.

Pileus convex to expanded, gregarious, 6-10 cm broad; surface white, distinctly imbricate-scaly, especially at the center, margin silky, widely projecting, fimbriate; context 1 cm. thick, white, unchanging, very sweet and nutty, not amygdaline; lamellae just free, close, inserted, 1 cm broad, pale a long time, entire; spores ellipsoid, smooth, dark, opaque, 5-6 × 4 μ; stipe equal, solid, glabrous, white, about 7 × 1.7 cm.; annulus ample, simple, white, fixed, median.

Type collected by W. A. Murrill in open manured cultivated ground at Gainesville, Fla., Oct. 17, 1941 *(F 19577)*. Suggesting *A. floridanus* Pk. but rough-scaly on the disk. Both cap and stem become yellow or brownish-yellow where bruised and golden-yellow when dried. As I have described *A. crocodilinus* from the West I thought an appropriate Florida name might be appreciated.

Agaricus Blazei sp. nov.

Pileo subcylindrico-subexpanso, 7-9 cm lato, squamuloso, cremeo ad ochraceo, non amygdalino; lamellis confertis, pallidis; sporis ellipsoideis vel ovoideis, 5 × 4 μ; stipite aequali, solido, 5-6 × 1.5-2 cm; annulo amplo, albo.

Pileus subcylindric to subexpanded, scattered or gregarious, 7-9 cm broad; surface finely scaly, cremeous to ochraceous, margin glabrous, white, even, entire, projecting 5 mm.; context white, unchanging, 1-1.5 cm thick, not amygdaline; lamellae free, inserted, close, 5 mm broad, entire, pale; spores ellipsoid or ovoid, smooth, dark, opaque, about 5 × 4 μ; sterile cells on edges of gills scarce, hyaline, irregularly clavate; stipe equal, solid, white, ochraceous when bruised, 5-6 × 1.5-2 cm; annulus large, white, median, simple.

Type collected by R. W. Blaze on his open lawn in Gainesville, Fla., Apr. 24, 1944 *(F 32911)*. Collected once by the author in the vicinity. Suggesting *A. xanthodermoides* Murr. and *A. floridanus* Pk. but distinct from both.

Agaricus citrinidiscus sp. nov.

Pileo convexo-subdepresso, 5 cm lato, subsquamuloso, disco citrino, margine pallido, appendiculato; lamellis liberis, confertis, ventricosis, sporis subellipsoideis, levibus, 5 × 3 μ; stipite pruinoso, pallido, bulboso, 6-8 × 0.5-0.8 cm; annulo amplo, demum citrino.

Pileus convex to slightly depressed, solitary, 5 cm broad; surface slightly squamulose, citrinous at the center and fading out toward the appendiculate, even margin; context very thin, white, unchanging, odorless, mild; lamellae free, inserted, ventricose, about 7 mm broad, rounded behind, crowded, entire, purplish-brown at maturity; spores subellipsoid, smooth, dark purplish-brown, about 5 × 3 μ; cystidia none; stipe enlarged downward, bulbous, smooth, glabrous and white above, pruinose and sulphureous below, 6-8 × 0.5-0.8 cm; annulus ample, fixed 2 cm from apex, sulphureous, citrinous when dry.

Type collected by W. A. Murrill on the ground in a high hammock at Gainesville, Fla., Aug. 11, 1944 *(F 32719)*. A rare and delicate woodland species.

Agaricus cylindriceps aureus var. nov.

Pileo pallido, flavo-squamuloso, demum luteo, amygdalino; sporis 5-6 × 3.5-4 μ; stipite aequali; annulo amplo.

Pileus usually cylindric at first, solitary or gregarious; surface pallid with small yellow scales, becaming luteous when handled or on drying; context with strong amygdaline odor; lamellae very pale: spores 5-6 × 3.5-4 μ; stipe equal, yellowish at the base, luteous when handled or dried; veil ample.

Type collected by W. A. Murrill on an open lawn in Gainesville, Fla., Oct. 23, 1942 *(F 20495)*. Also collected frequently in the vicinity from spring to fall on exposed or slightly shaded lawns or bare soil. Readily recognized by its strong amygdaline odor and its golden color when handled or dried. It quickly changes to yellow in KOH. Pleurocystidia are sometimes found. This is *A. amygdalinus* of Curtis, a name which was never published, but is not *A. auricolor* of Krieger, described from Maryland in 1927. I have observed this fungus closely for several seasons and am convinced that it is only a variety of my *A. cylindriceps*. At Camp O'Leno, in Columbia Co., Fla., I found the two growing together in a small opening in oak-pine woods. On the campus of the University of Florida the colonies are found closely associated and always appear as varieties rather than species. Dr. Coker kindly sent me specimens of Curtis's *A. amygdalinus* (nomen nudum) for comparison.

Agaricus pseudoplacomyces sp. nov.

Pileo convexo-plano, gregario, 8 cm lato, squamuloso, grato; lamellis angustatis, confertis; sporis 5-6 × 3-4 μ. stipite clavato, albo, glabro, 4-5 × 1-2 cm; annulo albo, amplo.

Pileus convex to plane or slightly depressed, gregarious, 8 cm broad; surface covered except on the disc with pale purplish-brown scales, margin less scaly, entire: context white, unchanging, about 5 mm thick, with agreeable odor and taste but not amygdaline; lamellae free, narrow, ventricose, crowded, entire; spores ellipsoid or ovoid, smooth, 1-guttulate, dark purplish-brown, 5-6 × 3-4 μ; stipe much enlarged downward, solid, smooth, white, unchanging, glabrous, 4-5 × 1-2 cm; annulus ample, simple, white, fixed near apex of stipe, fragile and apt to be lost in age.

Type collected by W. A. Murrill on a rich grassy lawn under a Canary-Island palm in Gainesville, Fla., May 24, 1944 *(F 20483)*. Suggesting *A. placomyces* but having a much shorter stipe and less slender spores. In old dark caps the scales have mostly disappeared.

Agaricus subcomtulus sp. nov.

Pileo convexo-expanso, umbonato, 2-2.5 cm lato, subsquamuloso, isabellino; lamellis latis, ventricosis, confertis; sporis ellipsoideis, 5-7 × 4 μ; stipite albo, 2.5 × 0.2 cm; annulo amplo, albo.

Pileus convex to expanded, broadly umbonate, gregarious, 2-2.5 cm broad; surface minutely scaly, isabelline, rosy-isabelline on the umbo, margin even, entire, upturned in age; context thin; lamellae free, inserted, broad, ventricose, close, entire, soon purplish-brown or blackish; spores pale, ellipsoid, smooth, 1-guttulate, about 5-7 × 4 μ; stipe equal above the

enlarged base, smooth, white, about 2.5 × 0.2 cm; annulus white, fixed about 1 cm from the apex.

Type collected by W. A. Murrill in leaf-mold in a high hammock at Gainesville, Fla., July 2, 1938 *(F 17335)*. Also found in the vicinity in a garden. First referred by me to *A. comtulus* Fr. and also suggesting *A. herradurensis* Murr. From the latter it differs in its larger spores, more slender stem and paler color.

Agaricus subponderosus sp. nov.

Pileo convexo-plano, 9-12 cm lato, squamuloso, albo, grato; lamellis angustatis, confertis, albis; sporis subglobosis vel ellipsoideis, 4-5 × 3.5-4 μ; stipite subfusiformi, albo, 10-12 × 2-4 cm; annulo albo.

Pileus convex to plane, gregarious, 9-12 cm broad; surface dry, distinctly squamulose, white, unchanging, margin thin, not projecting, appendiculate, soon lacerate, slightly upturned with age; context 2 cm thick, abruptly tapering at the margin, white, unchanging, tough, with pleasant odor and taste; lamellae free, inserted, much crowded, very narrow, only 5 mm, entire, white, pallid a long time; spores broadly ellipsoid, smooth, purplish-brown, 1-guttulate, about 4-5 × 3.5-5 μ; stipe subfusiform, solid, smooth, white, unchanging, subglabrous, 10-12 × 2-4 cm; veil white, simple, often breaking up, sometimes leaving an imperfect ring 2-4 cm from the apex.

Type collected by W. A. Murrill in rich soil in a high hammock at Gainesville, Fla., Apr. 12, 1944 *(F 21775)*. Suggesting *A. praemagniceps* Murr. and *A. subarvensis* Murr. but distinct from both. Remarkable for its narrow gills and long, thick stem.

Agaricus sulphureiceps sp. nov.

Pileo campanulato, 3-4 cm lato, subfibrilloso, sulphureo; lamellis albis, confertis, fimbriatis; sporis ellipsoideis, 5 × 3 μ; stipite bulboso, albo, 3.5 × 0.5-0.7 cm; annulo amplo.

Pileus campanulate to expanded, 3-4 cm broad; surface slightly viscid when wet, smooth, finely fibrillose, sulphureous, slightly deeper yellow on the disk, margin even, entire, projecting; context thin, pallid, odorless; lamellae free, close, narrow, white to blackish with white edges; spores ellipsoid, smooth, purplish-brown, about 5 × 3 μ; stipe enlarged downward to the rounded base, white, pale-yellow when dried, fibrillose below, about 3.5 × 0.5-0.7 cm, bulb 1.2 cm thick; annulus ample, fixed 1 cm from apex, tomentose beneath, becoming pale-yellow.

Type collected by W. A. Murrill in soil in frondose woods on the Newberry Road, seven miles west of Gainesville, Fla., June 18, 1944 *(F 38805)*. When dried the hymenophore is distinctly yellow with a dark-yellow disk. *A. comtuliformis* Murr., described from Alabama, is related but differs in color, habitat, length of stipe and the absence of a bulb.

Agaricus xanthodermoides sp. nov.

Pileo convexo-expanso, gregario, 6-9 cm lato, albo, pubescenti, grato, non amygdalino; lamellis liberis, albis, 6 mm latis; sporis ovoideis, 5-6 × 4-5 μ; stipite albo, solido, pubescenti, 4-7 × 1.1-5 cm; annulo amplo, albo.

Pileus convex to expanded, scattered or gregarious, 6-9 cm broad; surface dry, white, silky to slightly scaly, margin even, entire, projecting about 3 mm; context about 7 mm thick near stipe, white, unchanging, taste pleasant, odor not amygdaline; lamellae free, close, about 6 mm broad, abruptly tapering at ends, white, soon pale-pink, entire; spores broadly ovoid, smooth, purplish-brown, about 5-6 × 4-5 μ; stipe enlarged below, solid, white, pubescent, 4-7 × 1-1.5 cm; annulus ample, simple, white, persistent, fixed near apex of stipe.

Type collected by W. A. Murrill in short grass under a solitary loblolly pine in Gainesville, Fla., Mar. 25, 1944 *(F 22503)*. Resembling *A. projectellus* Murr. but turning orange in drying except when blackening with age. It is not usually cylindric when young and its odor is not at all amygdaline, thus differing from *A. cylindriceps* Murr. When the type was collected, *A. projectellus* was common but *A. cylindriceps* had not yet appeared. I have collected *A. xanthodermoides* a dozen times about Gainesville, mostly in early spring in open grassy or weedy ground. Smith says it is perhaps nearest to *A. xanthodermus* Genev., described from pastures in France. He found the spores very variable, 5-8 × 4.5 μ, and the abundant yellowish cheilocystidia to resemble basidia, measuring 18-22 × 8-12 μ. The cuticle of the pileus turns yellow in KOH.

Atylospora striatuliformis sp. nov.

Pileo conico-expanso, saepe umbonato, gregario, 2-3 cm lato, avellaneo, striato, margine albo, floccoso; lamellis adnatis, distantibus, fimbriatis; sporis ellipsoideis, 6-8 × 4 μ; stipite subbulboso, albo, atomaceo, 3 × 0.3-0.4 cm.

Pileus conic to expanded, often with a mammillate umbo, gregarious or scattered, 2-3 cm broad; surface avellaneous, dull, finely striate to the smooth, isabelline disk, margin milk-white, subentire, minutely floccose; context thin, pallid, odorless, mild; lamellae adnate with long decurrent ridges, ventricose, 5 mm or more broad, distant, very thin, inserted, slightly white-fimbriate when young, soon purplish-brown; spores ellipsoid, smooth, opaque, purplish-brown, about 6-8 × 4 μ; cystidia none; stipe equal above the enlarged base, white, shining, atomaceous, rigid-fragile, fistulose, about 3 × 0.3-0.4 cm.

Type collected by W. A. Murrill on a lawn under cabbage palms at Gainesville, Fla., Jan. 23, 1945 *(F 19407)*. Suggesting *A. striatula* Murr., described from N. Y., but with a much shorter stipe. The margin is not appendiculate enough for *Drosophila*.

Coprinus spragueiformis sp. nov.

Pileo convexo-subexpanso, gregario, 2 cm lato, plicato, subglabro, disco isabellino; lamellis angustatis, subdistantibus; sporis ellipsoideis, levibus, 12 × 6-7 μ; stipite aequali, glabro, pallido, 7-9 × 0.1-0.2 cm.

Pileus convex to subexpanded, gregarious, about 2 cm broad; surface plicate with isabelline disk and ridges, subglabrous, margin entire; context membranous; lamellae attached to a disk, inserted, subdistant, narrow; spores ellipsoid, smooth, opaque, black, about 12 × 6-7 μ; stipe equal, pallid, smooth, glabrous, shining, 7-9 × 0.1-0.2 cm.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., June 12, 1944 *(F 32925)*. Abundant on lawns in the vicinity after

rains during warm weather. Having the aspect of *C. Spraguei* B. & C. but with larger spores. Also suggesting *C. hemerobius* Fr., but having narrower spores and showing wider smoky furrows between the ridges on the cap.

Psilocybe longispora sp. nov.

Pileo convexo-plano, 1.5-2.5 cm, lato, sicco, glabro, subisabellino, striato, subfelleo; lamellis emarginatis, 4-5 mm latis; sporis oblongo-ellipsoideis, levibus, 15-18 × 5-6 μ; stipite pallido et castaneo, 4-5 × 0.1-0.2 cm.

Pileus convex to plane, gegarious, 1.5 to 2.5 cm broad; surface dry, glabrous, pale-isabelline, smooth, becoming slightly striate to the disk, margin entire, concolorous; context very thin, white, unchanging, odorless, soon slightly bitter; lamellae emarginate with quite a broad adnate base, inserted, medium distant, 4-5 mm broad, plane at first but becoming ventricose, brownish-mottled at maturity, edges white; spores oblong-ellipsoid, opaque, purplish-brown, smooth, 15-18 × 5-6 μ; basidia 4-spored; cystidia none; stipe tapered downward, hollow, lightly furrowed, pallid and white-chaffy above, chestnut and glabrous below, 4-5 × 0.1-0.2 cm.

Type collected by G. F. Weber on vegetable debris in a dried-up cypress pond in Cary Forest, east of Gainesville, Fla., Jan. 18, 1944 *(F 21011)*. Suggesting *Campanularius* at first sight, with its mottled white-edged gills, but striate and with totally different spores.

Stropharia coronilliformis sp. nov.

Pileo campanulato-convexo, 1.5-2.5 cm lato, cremeo et ochraceofulvo, grato, lamellis sinuatis, confertis, latis, albis; sporis ovoideis, levibus, 7-8 × 5-6 μ; stipite ochraceo-fulvo, fibrilloso-squamuloso, apice albo pruinosoque, 3 × 0.2-0.4 cm; annulo evanido.

Pileus campanulate to broadly convex, scattered, 1.5-2.5 cm broad; surface smooth, minutely subtomentose, pale-yellow to ochraceous-fulvous, margin even, white, slightly appendiculate; context thin, white, unchanging, odorless, mild; lamellae sinuate with decurrent tooth, inserted, close, broad, fimbriate, white to purplish; spores ovoid, smooth, 1-guttulate, purplish-brown, 7-8 × 5-6 μ; cystidia none; stipe tapering downward, white and pruinose above, ochraceous-fulvous and fibrillose-squamulose below, about 3 × 0.2-0.4 cm; veil evanescent, leaving no annulus or only a small one.

Type collected by W. A. Murrill on an open grassy lawn in Gainesville, Fla., July 14, 1944 *(F 32831)*. Frequent on lawns in the vicinity during the summer rains. Suggesting *S. coronilla* (DC.) Quél. but considerably smaller and with very different spores.

Polyporus Gratzianus sp. nov.

Pileo 12 cm lato, tomentoso, roseo-isabellino, anisato; tubulis parvis, albis; sporis ellipsoideis, levibus, 6-7 × 4-5 μ; stipite centrali, tomentoso, umbrino, 3 × 3 cm.

Pileus circular or irregular, often laterally connate, about 12 cm broad; surface conspicuously pubescent to tomentose, uneven, rosy-isabelline with bluish blotches, umbrinous at the center, margin white, undulate, thin, even; context tough, pallid, zoned, discolored when cut, tasteless, with

anise odor, 1-2 cm thick; tubes adnate, small, short, white with a rosy tint; spores broadly ellipsoid, 1-guttulate, smooth, white, 6-7 × 4-5 μ; stipe short, central, woody, tomentose, umbrinous, reaching 3 × 3 cm.

Type collected by W. A. Murrill on buried dead oak roots at Burnett's Lake, Alachua Co., Fla., July 4, 1943 *(F 32996)*. Also collected at the same time on dead sweet-gum roots, and on the same host by A. S. Rhoads near Gainesville. The cap and tubes turn yellow on drying.

New Combinations

For those using Saccardo the following species are recombined:

Atylospora striatuliformis = **Psathyra striatuliformis**
Cortinellus imbricatus felleus = **Tricholoma imbricatum felleum**
Gymnopilus praelaeticolor = **Flammula praelaeticolor**
Gymnopus omphalina = **Collybia omphalina**
Melanoleuca silvaticoides = **Tricholoma silvaticoides**
Melanoleuca subcylindrispora = **Tricholoma subcylindrisporum**
Melanoleuca subvolkertii = **Tricholoma subvolkertii**
Monadelphus subilludens = **Clitocybe subilludens**
Monadelphus umbriniceps = **Clitocybe umbriniceps**
Venenarius malodorus = **Amanita malodora**
Venenarius subcitriniceps = **Amanita subcitriniceps**
Venenarius subphalloides = **Amanita subphalloides**
Venenarius subrecutitus = **Amanita subrecutita**
Venenarius verniformis = **Amanita verniformis**

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of the

LOWER FLORIDA KEYS

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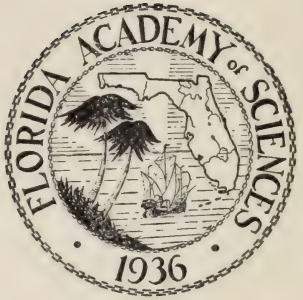

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1946

BIRDS OF THE LOWER FLORIDA KEYS

including the

GREAT WHITE HERON AND KEY WEST NATIONAL WILDLIFE REFUGES

EARLE R. GREENE

New Orleans, Louisiana

Bird life on the Florida Keys has been studied for more than one hundred years. Ornithologists from the time of Audubon have made occasional trips to the keys, chiefly during the winter time, and have published reports on the birds they observed. A few students, especially in recent years, have also spent the summer months there and have made brief reports on their findings.

The author of this paper served as manager of the Great White Heron and Key West National Wildlife Refuges, for the Fish and Wildlife Service (formerly the Biological Survey), U. S. Department of the Interior, from February, 1939, until October, 1942. This assignment was to provide a resident protector for the fast diminishing Great White Herons, as the area constitutes their principal nesting grounds. The study and protection of this great bird was the writer's primary concern, but the undertaking also permitted observation of other interesting birds, and of the wildlife in general.

The Key West National Wildlife Refuge consists of keys or islands lying southwestwardly from the city of Key West, and was established on August 8, 1908, by Executive Order No. 923 of Theodore Roosevelt. The Great White Heron National Wildlife Refuge, consisting of those keys on the Gulf side of the main highway keys in lower Florida Bay, was established on October 27, 1938, by Executive Order No. 7993 of Franklin D. Roosevelt. For the sake of brevity they are called simply the Great White Heron and Key West Refuges in this paper.

In addition to the two refuges, the principal keys from Key West to Big Pine Key were under regular patrol and study. On Big Pine Key and a few others a small remnant of the Key deer survives.

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The plant life of these keys is semi-tropical and tropical, and on many of them (especially the island of Key West) a number of exotic plants abound, brought in over the years from many foreign ports, and making the area one of intense interest to botanists. Most of the keys are covered with a heavy growth of mangrove, including three species—the red mangrove *(Rhizophora mangle)*, black mangrove *(Avicennia nitida)*, and white mangrove *(Laguncularia racemosa)*. Many of the keys are partially submerged at high tide. A few have open areas and sandy beaches.

Although the area studied lacks numerous well known species of birds that are found farther north, and is not in the direct line of migration for many forms, those found here are of extreme interest, and some of them are not to be seen anywhere else in the United States. West Indian forms of tropical affinities, as well as wintering birds of western distribution, add to the ornithological interest of the region.

The names of Audubon, Maynard, Atkins, Holt, Bent, Chapman, Howell and others are closely associated with the ornithology of the keys. A house is still standing (1942) in Key West which is said to have been occupied in 1832 by Audubon.

No attempt is made in this paper to present a complete account of the ornithology of the Florida keys; it is simply a report on some of the observations and collections made by the author during the approximately three and one-half years during which he was manager of the two refuges.

Many ornithologists and bird students from various parts of the United States have visited these refuges and contributed valuable information and advice to the writer. In addition, a number of local residents were of great assistance and influence in the protection of wildlife. To all of these, grateful acknowledgement and thanks are extended.

Special credit must be given to the following: Stephen C. Singleton, Secretary of the Key West Chamber of Commerce, for much useful information about the keys, and for exerting his influence toward the protection of all wildlife; John H. Davis, Jr., for identification of much of the flora of the keys; Augustus S. Houghton of New York City and Coconut Grove, Florida, for information and companionship on many trips; Mr. and Mrs. Earl Sycks for the use of their botanical garden on Stock Island

for investigations, and for much information about the plants contained therein; William Demeritt for information, especially that drawn from his years of banding birds in Key West; Mr. and Mrs. Wallace B. Kirke for many favors and aid in bird protection; Julius Stone of Key West for continual encouragement and backing in these studies; and Charles Thompson for valuable assistance on several field trips.

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Joseph E. Warren of Key West, a faithful patrolman, was the author's companion on most of the many trips made throughout the area. Miss Harriet Stokes typed the manuscript of this paper, and Miss Susebel Bridges aided in checking and copying the final draft. The services of Miss Stokes were lent, at the suggestion of Dr. James Nelson Gowanloch, by the Louisiana Department of Conservation. To all of these thanks are extended for the assistance rendered.

The nomenclature used is that of the Fourth American Ornithologists' Union Checklist (1931), except in the instance of the Athens Yellowthroat *(Geothlypis trichas typhicola)*, which was not described until 1934.

Earle R. Greene

New Orleans, La.
October, 1944.

ANNOTATED LIST

Common Loon

Gavia immer immer (Brunnich)

A winter resident in this area, occurring in December, January, February, and March. December 25, 1939, earliest, and March 18, 1941, latest, date seen. On January 30, 1940, twenty-nine loons were observed in the waters between Key West and Sand Key. Oil-soaked or injured individuals were frequently noted.

Horned Grebe

Colymbus auritus Linnaeus

An uncommon winter resident in these waters. My only records are as follows: On February 10, 1940, one bird was observed off Sugarloaf Key in the waters of the Atlantic; on January 7, 1941, one was seen off Fleming Key near Key West.

Pied-billed Grebe

Podilymbus podiceps podiceps (Linnaeus)

A winter resident, inhabiting the small ponds and ditches along the lower keys. My earliest note of arrival is November 17, 1941, and the latest date on which it was seen is March 18, 1941. All of the rather frequent observations have been of single birds or of two at the most. Key West, Stock Island, Boca Chica Key, Geigers Key, Sugarloaf Key, and Big Pine Key all harbor a few individuals of this species during the winter months.

Eastern Brown Pelican

Pelecanus occidentalis occidentalis Linnaeus

A permanent resident among the keys, more abundant during the winter months when its numbers are augmented by birds from farther north. Pelicans are seen throughout both refuges and south to the Marquesas Keys; they are common around the docks and piers of Key West, where they are fed by fishermen and tourists. At one dock, when the fishing boats arrive in port, they mingle with cats and dogs, which have a healthy respect for their huge beaks.

Fig. 1.—Map of the Great White Heron and Key West Refuges. Drawn by A. M. Laessle.

On July 2, 1940, a nesting site was located on a small key off the Gulf side of Sugarloaf Key. Eleven nests were counted, most of them in a dilapidated condition as the young had left, although fifteen immature birds were counted on the limbs and branches of the mangrove trees. One nest contained two eggs. Many dead small fishes were found in the water below the nests.

An interesting and rather amusing incident was noted off South Beach, Key West, on an August day. A pelican, intent only on its fishing, was pursued by a laughing gull. The pelican would dive into the water for the fish, and when it came up the gull would alight on it, generally on its back. I thought at first that the gull would grab at whatever fish the pelican tried to swallow, but apparently this was not the idea. Each time the pelican flew about, the gull would follow and light on its back for a few seconds or minutes, apparently for the ride. This performance did not seem to worry the pelican at all, as it kept right along in its search for food.

White-bellied Booby

Sula leucogaster leucogaster (Boddaert)

The following are my only records: October 12, 1939, one was seen on buoy No. 8, and one more on another buoy nearer Sand Key, between Key West and Sand Key a few miles off Key West; July 30, 1940, one bird on a marker near Fort Jefferson, Dry Tortugas. This last location is about 65 miles west of Key West.

Gannet

Moris bassana (Linnaeus)

Although undoubtedly occurring in numbers offshore at times during the winter months, my only record is of nine birds (apparently one adult and eight in immature plumage) seen from Key West on December 29, 1941. They were flying a little above the water in a southwesterly direction toward the Key West Refuge. A rather strong "norther" which had blown all night was continuing during this day.

Florida Cormorant

Phalacrocorax auritus floridanus (Audubon)

Permanent residents among the keys, "nigger geese" are common on the channel markers and on a number of the keys of both

refuges, as well as about the ponds of Key West and the main highway keys extending to the mainland of Florida.

Cottrell Key in the Key West Refuge has supported a rookery for many years. On March 5, 1941, this was visited by the writer and Joe Warren, his boatman. About 200 birds were flying about as we approached from Northwest Channel, and as we came alongside many young of the year flew off their nests to the water, apparently having left the nest only recently or perhaps taking off for the first time. From 50 to 100 nests were located in the mangrove trees near and over the water, about 90 per cent of them empty, although they had been used that year. A few young, probably unable to fly, remained on the nests. All of these nests were on the side of the key away from the open waters of the Gulf.

Several thousand cormorants use the keys and waters of the refuges. It is presumed that many of the birds seen during the winter months are of the double-crested form, *P. a. auritus,* although specimens are lacking to verify this.

Man-o'-war-bird

Fregata magnificens Mathews

The keys offer a rare opportunity to witness this wonderful flier at its best. There is always a thrill in seeing one of these birds sweep down from high in the air to pick up some morsel of food from the surface of the water. Although frigate birds may be seen on several keys in some numbers, one need go no farther than one of the docks or piers of Key West to observe them; often several may be seen perching on the roof of some old building for a few minutes before taking to the air again. They never rest upon nor dive beneath the water, but scoop up their food from the surface by expert maneuvering. As predators, they will chase a tern, if necessary for miles, to make it drop its food, which is caught by the frigate bird before it reaches the water. I suspect them strongly of breaking up nests of herons by stealing the eggs, although I have not yet seen this happen.

Only occasionally did I see individuals with inflated throat pouches—a remarkable sight, as they fly overhead or against some dark mangrove, the pouch appearing like a toy balloon or reddish-glowing lantern.

Man-o'-war-birds are seen during every month of the year; many are in immature plumage, but no nests have yet been found in the Florida keys.

Great White Heron
Ardea occidentalis Audubon

Although this magnificent bird has been the subject of special study by the writer since February, 1939, and its protection was one of the chief reasons for his transfer to this area, it is not proposed to give a complete life history in the present paper but to leave fuller consideration to a subsequent article.

Suffice it to say that market hunters, "eggers," and especially the hurricane of 1935 brought this species to the verge of extinction. In October of that year Alexander Sprunt, Jr., of the National Audubon Society, as a result of counts and a close estimate, could report only 146 birds in nine-tenths of their range.

During the time I was stationed at Key West—February, 1939, to October, 1942—I made many trips by boat throughout the area from Noname Key to the Marquesas Keys, as well as by car and on foot on the keys traversed by the Overseas Highway, so that fairly accurate counts of this great bird were made over most of its habitat. Using a Coast Guard plane, one inspection flight was made from Miami to the Marquesas and return, and another from Miami over much of the lower Everglades and Cape Sable country. However, the area comprising the Great White Heron and Key West Refuges was the one under constant patrol, and by far the greater part of my notes were made there and along the rest of the lower keys. Information was kindly furnished by other observers as to the status of the Great White Heron among the upper keys from the Matecumbes to the mainland.

Owing to shallow water over most of the area and changes due to tides, and to the difficult flats, marshes, and mangrove jungles, the territory was an extremely hard one to work. The millions of mosquitoes and other insect pests, the tropical sun, and considerable stormy weather were further handicaps to study of the area. Despite these factors, however, the search for information on this and other birds was extremely interesting and the results obtained were well worth the effort.

As a result of continual protection and patrolling, as well as of educational efforts in Key West and on the other keys, by the

fall of 1942 the Great White Heron population had increased to approximately 1,500 to 1,800 birds. Some arrests for refuge violations were made during this four-year period, and probably some birds were killed that the writer never learned about.

It is not believed that the race is very prolific, and as it is restricted in its distribution to the mangrove keys and interbreeds with the Ward's Heron *(Ardea herodias wardi)*, its increase is slow. There is the possibility also that mating with Ward's, producing the hybrid, Wurdemann's Heron *(Ardea wurdemannii)*, may in time completely eliminate the pure strain of the Great White. At the present time, however, this possibility seems remote.

Nests containing eggs and young were found on many keys, including Snipe, Round, Scott's, Harbor, Bill, Big Crane, Cottrell (Key West Refuge), Little Crane, Pass (off Sugarloaf), and the Bay Keys. Nesting results were extremely favorable on Crane, Snipe, and the Bay Keys where intensive studies were made.

Eggs or young were found in the nests during the months of November, December, January, February, March, and April. All nests were bulky affairs made chiefly of mangrove sticks, generally with a few leaves for lining, and hardly different from those of the Ward's Heron. As the eggs also are of practically the same size and color, determination of the ownership of nests was at times difficult. The majority of the nests were from four to fifteen feet above ground or water.

Outstanding population counts may be summarized as follows:

1939—March 10 (with Harold S. Peters), 55 birds on a trip from Key West to Snipe Keys; March 13, 93 or more birds, the Marquesas Keys; March 16, 40 birds, about Fleming, Johnston, Michael, Budd, Raccoon, Mayo, and Little Pine Keys; May 5, 30 birds, on trip Noname to Key West; May 11, 67 birds, the Marquesas; August 7, 68 birds, the Marquesas; December 14, 74 birds, Marquesas.

1940—October 21, 33 birds, Mud, Eagle Nest, and Harbor Keys, and Calda Channel; November 6, 55 birds along Calda Channel, a favorite feeding place at low tide; 31 near Bay Keys; December 30, 31 birds, Calda Channel, Harbor, Mud, and Snipe Keys.

1941—January 7, 31 birds, Bay, Harbor, Snipe, Annette, Johnston, Torch, and Water Keys; February 26 (with Harold S. Peters in Coast Guard plane from Miami over many of the keys to Key West and the Marquesas and return, four and one-half hours), my count 303 birds, Peters' count 516; February 27 (with Peters and Jay V. Kelsey in Coast Guard plane from Miami to Cape Sable, Whitewater Bay, Card Sound,

Fig. 2.—Great White Heron. Great White Heron National Wildlife Refuge, Key West, Florida. Photograph by Howe Sadler, April 22, 1942, for the Fish and Wildlife Service.

Fig. 3.—Great White Heron (not fully mature). Big Crane Key, Florida. Photograph by Earle R. Greene, January 23, 1941, for the Fish and Wildlife Service.

Barnes Sound, Flamingo and other keys off mainland), Kelsey, one side of plane, 16 birds, my count, other side, 38 birds, Peters in front with pilot, 35 birds; April 17, 85 birds, Marquesas (Joe E. Warren); December 26, 52 birds, on a circuit of Bay, Cayo Agua, Harbor, Eaglenest, Snipe, Mud, Harbor, and Bay Keys, Calda Channel, Boca Chica, and Key West.

1942—January 16, 48 birds feeding out from Crane Key; February 6, 93 birds, on a trip from Bay to Noname Keys; July 23, 45 birds, Marquesas Keys (Joe E. Warren).

Mention might be made also of records by the author of Great White Herons seen at some distance from the refuge area: April 18, 1939, one bird near the Tamiami Trail about 14 miles west of the road southward to Homestead; and July 18, 1939, one bird over the Indian River at Jensen, Martin County, Florida. On March 17, 1941, Mr. Brinson of the National Park Service told me that one Great White Heron had been seen recently on Bush Key in the Dry Tortugas.

Some of the many nesting records follow:

1939—Snipe Keys: February 20, 1 nest containing 2 eggs, 1 with 1 egg and 1 young bird, 1 containing 2 young birds, both of which snapped and squawked at me, 2 nests unfinished, 1 containing 1 white, and 1 dark-brownish bird, both almost grown, that were tame and showed no fight (see also under Wurdemann's); March 7, same nest as on February 20, containing 1 Great White and 1 Wurdemann's immatures, both birds getting off nest on our approach, thus being considerably more active than before. "Wurdy" went back to the nest but "Whitey" stayed off while we were in that vicinity. November 8, Scotts Key: 1 nest containing 3 eggs, either Great White or Ward's. November 10, Snipe Keys: 3 nests containing 3 eggs each (Great White or Ward's). December 10, Snipe Keys (see also December 5, Ward's): 2 nests containing 3 young birds each, 1 with 2 young and 1 egg, 1 containing 1 young and 2 eggs. December 28, Snipe Keys: 1 nest, possibly Ward's, containing 4 eggs.

1940—January 11, Scott's Key: 1 nest containing 2 birds and 2 eggs (Warren), and 1 with 2 eggs. January 31, Snipe Keys: 1 nest contained 1 egg, 2 with 4 eggs each, 3 having 2 birds each and 1 with 3 birds (all reported by Warren). February 2, Snipe Keys: 1 nest with 4 eggs, 1 with 2 eggs; 1 with 2 Great White young, and 1 with 3 eggs. March 12, Snipe Keys: 1 nest with 2 very young with white down, 1 contained 1 egg and 1 downy young, 1 nest had 3 downy young. (Young of the Great White can always be told from those of Ward's Heron by their white plumage). December 10, Houghton Key of the Snipe Keys: 2 nests with 4 eggs, 2 with 3 eggs, 3 with 2 eggs, 1 with 1 egg; December 18, one of same nests, containing 4 eggs as reported December 10; December 30, all nests empty, apparently deserted (possibly due to intruders).

1941—January 8, Bill Key off Torch Key: 1 nest with 1 young bird that walked off nest at our approach, 1 nest had 3 eggs, and about 6

nests were unoccupied. January 23, Big Crane Key: 2 nests with 1 young each, and 2 with 3 eggs each. March 5, Cottrell Key: 1 nest containing 2 young and 2 eggs. March 12, Crane Key: 1 nest with 1 young, 1 with 2 young, and 7 empty. April 4, Houghton Key of the Snipe Keys: 1 nest with 1 young and 1 egg, 1 with 1 young (Great White) and 1 larger, gray (Wurdemann's—"Wurdy" climbed out of nest), 1 nest with 1 young gray (Ward's or Wurdemann's), 1 with 3 eggs, 1 with 2 eggs. April 18, Marquesas Keys: 7 nests containing 2 small birds each (Warren). November 19, Houghton of Snipe Keys: 1 nest with 4 eggs (possibly Ward's Heron), 1 nest having 4 eggs, 3 nests with 3 eggs each, 1 with 1 egg, 2 containing 2 young and 1 egg each. Pass Key off Sugarloaf: Nest containing 4 birds (2 well grown, 1 medium size, and 1 small). November 24, Bay Key: 1 nest containing 2 young and 2 eggs. December 10, Houghton of Snipe Keys: 1 nest with 1 small bird and 3 eggs, 1 nest having 3 eggs, reported by Warren.

1942—January 15, Crane Key: 1 nest containing 1 pure white bird and 1 gray bird (Wurdemann's; the white was more advanced and climbed away from nest), 3 nests with 2 birds each, 2 having 1 bird each, 1 nest holding 2 birds and 1 egg, 1 containing 1 dead bird, 1 with 2 birds (1 dead). One Great White flew off the key and alighted, floating on the water, then walked to land—an unusually tame young bird. February 12, Big Crane Key: 5 nests containing 1 egg each, 2 with 2 eggs each (Warren). Little Crane Key: 1 nest with 3 eggs, and 1 with 1 egg (Warren). April 7, Bay Key: 1 nest, No. 1, about 15 feet up in a buttonwood tree, containing 2 eggs; another, nest No. 2, with 3 eggs; April 14, nest No. 2, 3 eggs still in nest. On Perret of Bay Keys: 1 nest with 1 egg, 1 having 2 small birds and 2 eggs, 1 with 3 eggs, 1 containing 2 well-developed young. On Bay Key, nest No. 2 on April 21 held 1 young just hatched and squawking, plus 2 eggs. April 22, Perret Key: nest containing 2 young and 1 egg, 2 with 2 young, 1 containing 3 eggs, 1 with 3 birds and 1 smaller "runt" on ground which we replaced in the nest.

Number of broods per year—The finding on January 8, 1941, of a nest containing 3 eggs on Bill Key and the broken shells of 2 or 3 eggs directly underneath suggests that more than one brood may sometimes be reared.

Mating—On March 20, 1942, off Scott's Key, an adult Great White Heron was observed chasing an adult Ward's Heron, the Ward's apparently leading the white one on, stopping on a sandbar then again flying a short distance.

Feeding areas—A number were favored, one of the most noticeable being along Calda Channel off Key West when the tide was low and much of the area became dry. At such times dozens of birds could be seen wading about and feeding as well as perching

Fig. 4.—Eggs and nest of Great White Heron. Snipe Keys, Florida. Photograph by Harold S. Peters, March 10, 1939.

Fig. 5.—Immature Great White and Wurdemann's Herons at nest. Snipe Keys, Florida. Photograph by Harold S. Peters, March 10, 1939.

Fig. 6.—Nest and four eggs of Great White Heron. Snipe Keys, Florida. Photograph by Maurice Broun, January 31, 1940.

Fig. 7.—Great White Heron on nest. Great White Heron National Wildlife Refuge, Key West, Florida. Photograph by G. Edgar Folk, Jr.

on the channel markers. At high tide the birds made for the mangrove jungles of the keys.

Food—Although small fishes and other aquatic organisms are known to be the usual food of these herons, I saw some evidence that snakes may at times be taken. On June 23, 1939, a bird was closely watched on Trumbo Island, a part of Key West. It had a long snake, species unknown, which it almost completely swallowed before I left the scene. Again, on September 21, 1942, I was told by a reliable person in Key West that she had recently seen a Great White Heron, standing near the Casa Marina Hotel, with a live black snake wrapped about its neck. The bird was apparently making efforts to extricate itself from the coils of the snake, and when she approached it took wing with the snake hanging on. Probably the bird had caught the snake for food but was having a hard time subduing it.

Abnormalities— A number of birds with oil on their plumage were seen. Some of this probably originated in refuse from a dumping area. Great White Herons with blackish spots on the breast, sides and wings attracted attention and were commented upon by many people. At times unable to fly, they appeared to seek the aid of man, as a number of birds came to house yards and one even to a business establishment—appropriately enough, the city laundry! Occasional dead adults and a few dead young birds were noted. On one occasion two birds, apparently adults, with the breasts destroyed, were found lying in a nest, their feathers on the ground. The agent responsible was not determined.

Tameness—Instances of unusual tameness on the part of these birds were noted, although it must be stated that as a rule the Great Whites are much wilder than the Ward's Herons. One bird for many weeks frequented the dock area about Lowes Fish Market, and partook of the fishes discarded by incoming fishermen; several Ward's Herons behaved likewise. The Great White would approach to seize fish tossed to it on the dock, although it seemed to measure the distance between itself and its benefactor. Several people made good photographs at close range—20 feet or possibly less.

Ward's Heron

Ardea herodias wardi Ridgway

This, the Florida representative of the Great Blue Heron, is a permanent resident among the keys and a common sight on the sandbars and lagoons along the Overseas Highway. As a rule, it is much more approachable than is the Great White Heron.

The relationship of this race to the Great White Heron, a subject of much discussion over a number of years, appears to have been settled; I shall therefore deal with other topics, accepting in that respect the findings of A. C. Bent, E. G. Holt, and Arthur Howell.

Ward's Heron occurs throughout the area of the two refuges and the other lower Florida keys, and at times is abundant. A few of the many counts made are here recorded:

1939—March 13, 9 birds, one of which appeared to be a Wurdemann's, were seen from a distance about the Marquesas Keys, the western extremity of the Key West Refuge. March 22, 18 birds were noted about the Bay Keys in Great White Heron Refuge. Scattered birds were seen throughout the length of the refuges at all seasons of the year.

1940—February 23, 13 birds, and May 15, 9 birds, about the Snipe Keys. October 21, 1 off Eaglenest, 1 off Mud Keys, 5 off Harbor Keys, 9 off Calda Channel, feeding. November 6, 20 birds along Calda Channel at low tide, feeding. December 10, 16 birds at Snipe Keys.

1941—December 26, 35 birds, 1 juvenile, Bay Keys.

1942—May 18, about Mule, Archer, Mullet, Womans, Man, Barracuda, and Boca Grande Keys, a total of 34 birds was counted by Joe E. Warren.

Nests, Eggs and Young—Many nests, eggs, and young were inspected during the period, some of which are listed here:

1939—February 20, Snipe Keys: 1 nest containing 2 eggs, 1 nest with 1 egg and 1 young, 1 holding 2 young birds (both at the snapping and grunting age), 2 nests unfinished, 1 containing 1 white and 1 dark bird, almost grown, that were very tame and showed no fight. (These nests were all either Ward's or Great White. See also March 7, under Great White and Wurdemann's herons). March 10, Snipe Keys: 1 nest containing 2 Ward's or Wurdemann's young, another with a similar brood (Peters), 1 containing 3 eggs, 26 other nests reported by Peters and Warren. March 22, Bay Keys: 1 nest 2 young, and 1 with 1 young. November 10, Snipe Keys: 1 nest had 3 eggs, another with 3 eggs, 1 more with 3 eggs, and several nests in the making. (All these were apparently Great White or Ward's herons' nests, more of the former than the latter). December 5, Snipe Keys: Silver, Warren and the writer found: 1 nest containing 3 young, 1 with 1 large young and 2 eggs, 2 holding 2 birds

Fig. 8.—Ward's Heron. Trumbo Island, Key West, Florida.
Photograph by Earle R. Greene.

Fig. 9.—Ward's Heron (immature, on nest). Perret Key of the Bay Keys. Photograph by Howe Sadler, April 22, 1942.

Fig. 10.—Reddish Egret (white phase). Sugarloaf Key, Florida. Photograph by C. Blackburn Miller, March 10, 1940.

and 1 egg each, 1 with 3 eggs, 5 new nests with no eggs or young as yet. December 28, Snipe Keys: 1 nest with 4 eggs was unusually large; it was about 5 feet above ground in mangrove, and made of heavy sticks with smaller sticks and leaves for lining (possibly Great White). There were also several empty nests.

1940—February 2, Snipe Key: 1 nest containing 2 young birds, 1 with 3 young. February 23, Snipe Key: 1 nest with young Ward's or Wurdemann's, almost grown, standing on top, 1 containing 1 egg and 2 dead young (apparently a Great White and Wurdemann's, cause of death undetermined—possibly cold weather). March 12, Snipe Key: 10 empty nests; 1 nest containing 1 Ward's or Wurdeman's, almost grown; 1 more nest holding 1 bird almost grown, Ward's or Wurdemann's, one dark dead bird on ground; 1 nest containing 2 birds, Ward's or Wurdemann's, almost grown; 1 with 2 Ward's, very dark, large, and on the verge of leaving nest.

1941—January 23, on small key off Blake Key: 1 nest containing 1 almost grown bird which climbed out of nest, fell down, then with help of its bill regained its footing. December 10, Snipe Keys: 2 nests with 1 young bird each reported by Warren.

1942—January 15, Crane Key: 1 bird on, and 1 off, nest, both well developed, that off the nest being almost full grown. March 10, Snipe Keys: 1 nest containing 3 eggs. March 20, off Scott's Key: 1 bird being chased by Great White (see under Great White). April 7, Bay Keys: 1 nest, No. 3, about 12 feet up, containing 2 birds, bowing and snapping toward me, possibly 2 weeks old. April 10, nest No. 3, Bay Keys: 2 young birds still on nest. April 14, Bay Keys, nest No. 3: 2 young on nest, larger than before, 1 of them striking out and uttering angry guttural notes, sounding almost like a young dog. On Perret of Bay Keys: 1 nest holding 1 young and 2 eggs; 1 containing 2 well developed young both striking out and uttering angry notes; 1 about 20 feet up, with 1 or more young. April 22, 1 nest, low (about 4 feet), containing 1 bird almost grown, striking out and uttering notes, Perret of Bay Keys. Nest about 10 feet up, and with 3 young birds (Sadler), Perret of Bay Keys. May 21, 1 young bird, almost grown and distinctly marked, standing on low nest, Perret Key of the Bay Keys (photographed by Sadler on April 22). Nest No. 3 on Warbler of the Bay Key group held 1 young bird, almost grown and standing up; no other young seen in this nest.

Feeding areas—These are the same as for the Great Whites with which the Ward's Herons mingle. Calda Channel at low tide is a favorite.

Habits—More fearless than the Great White. One well known individual, which stayed for many weeks about the end of Trumbo Island where much fishing was done, was in the habit of stealing from the catches as well as the bait of the fishermen, and had to be chased away from time to time. Several were seen

about Lowes and other fishing docks waiting for the daily catch of fish to arrive, when they got their share from fish tossed away.

Wurdemann's Heron

Ardea wurdemannii Baird

(=*Ardea occidentalis* Audubon × *Ardea herodias wardi* Ridgway)

This hybrid between *occidentalis* and *herodias wardi* was frequently seen. Its status and relations to the other two herons have been the subject of much study and discussion, and the reader interested in this matter is referred to publications by Holt,[1] Bent,[2] Howell,[3] and Chapman.[4] The last-named authority states *(op. cit.)* that *wurdemannii* is intermediate between *occidentalis* and *wardi*, and is doubtless a hybrid between them. My own observations support most of the conclusions reached by these ornithologists, and in particular the view that Wurdemann's Heron is a hybrid between the other two.

Bent *(op. cit.*, p. 99) notes that hybrids between closely related species are fertile and may interbreed with pure-blooded birds of either parent stock. A number of the herons which I saw in the lower keys were neither definitely dark like a typical Ward's Heron, nor as white in certain areas of the plumage as Wurdemann's is supposed to be; they had dark or blackish markings on the crown. Judging from the genetic behavior of other organisms, such individuals might result from back-crossing of Wurdemann's with Ward's Heron, or be the darker individuals of a variable F_2 generation produced by a pair of Wurdemann's Herons. Perhaps such atypical birds may originate in both ways.

My records of Wurdemann's Heron are for the lower keys from the Bahia Honda bridge to the Marquesas. These keys are

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[1]Holt, Ernest G. 1928. The status of the Great White Heron *(Ardea occidentalis* Audubon) and Wurdemann's Heron *(Ardea wurdemannii* Baird). The Crile Florida Expedition, 1923-1924. *Sci. Publ. Cleveland Mus. Nat. Hist.*, 1 (1) : 1-35, pls. i-vi. Cleveland, Ohio.

[2]Bent, Arthur C. 1926. Life Histories of North American Marsh Birds. *U. S. Nat. Mus. Bull.*, No. 135. Washington, D. C.

[3]Howell, Arthur H. 1932. *Florida Bird Life.* Published by the Florida Dept. Game and Fresh Water Fish, in coop. with Bur. Biol. Surv., U. S. Dept. Agr. (Coward-McCann Co., Inc.). New York.

[4]Chapman, Frank M. 1932. Handbook of Birds of Eastern North America. (D. Appleton Century Co., Inc.). New York and London.

of coral formation, and most of them are thickly covered with red and black (and a few white) mangroves. The bases of many of the keys are submerged at high tide, while others, larger and older, have sandy beaches and dry soil, and even some open grassy areas. The Great White Heron Refuge includes much shallow water, which at times is impossible to navigate. The Key West Refuge also is very shallow in parts, but includes some areas of deeper water.

For a time after my arrival I called all dark herons Ward's, and the others with whiter heads and other light areas of plumage Wurdemann's. However, on finding a number of intermediates, I realized that there must be considerable mixing. As many observations were made from a distance and from boats, the exact status of many of the birds seen could not be determined. Often, however, a bird with a white head and other light areas stood out distinctly from its darker companions. Sometimes there appeared to be more Wurdemann's than the darker Ward's Herons. One bird seen at Big Pine Key, near the northern extremity of the Great White Heron Refuge, had a white head and neck, and much of the wing was light-colored. On March 10, 1939, nine herons, one definitely Wurdemann's, were seen at the Marquesas. All types were seen throughout the refuge area. On February 2, 1940, at Snipe Keys, more of the Wurdemann's type were observed than of birds that could be definitely identified as Ward's Herons; and in April, June, and November, five or six light-colored birds were seen feeding at times along Calda Channel. On December 26, 1941, eight Wurdemann's Herons were counted on the Christmas Bird Census. In 1942 scattered individuals of this hybrid were recorded throughout the area.

Nests of special interest were found and recorded as follows:

1939—February 20: A nest on one of the Snipe Keys, in a mangrove, containing 1 white and 1 dark bird, both almost fully grown and very tame. March 7, same nest: the birds were more active than before, getting off the nest at our approach; the Wurdemann's went back into the nest when Warren came closer, but the Great White stayed nearby. March 10, same nest: both birds left, "Wurdy" coming back, but we were unable to get "Whitey" to return.

1940—March 12, on one of the Snipe Keys: A nest containing 1 young great white and 1 dark bird, both well grown; the "Wurdy," further advanced, left the nest.

1941—April 4, on Houghton Key of the Snipe Keys: A nest containing

1 small great white and 1 larger gray Wurdemann's; the latter climbed out of nest. In this nest there was part of a fish, possibly a mullet.

1942—January 15, on Crane Key: A nest contained 1 pure white and 1 gray bird; both were almost grown, but the white one was more advanced and climbed away from the nest.

American Egret

Casmerodius albus egretta (Gmelin)

Occasionally seen but not common on the lower keys, and apparently does not breed here. Single birds have been seen on Key West and on Boca Chica and Saddlebunch Keys, and as many as four were observed feeding along Calda Channel between Key West and the open waters of the Gulf. My records are from August 5 to March 30.

Snowy Egret

Egretta thula thula (Molina)

Apparently does not breed on the lower keys and is not at all common. One or two birds may be seen at almost any time of the year, however, and on May 3, 1940, eight were noted about a small pond on the island of Key West.

Reddish Egret

Dichromanassa rufescens rufescens (Gmelin)

On the verge of extinction in Florida, from reports along the keys it is apparent that this species may be increasing again. On May 21, 1939, one was shown to me by Ed Moore, representative of the Audubon Society in Key West at that time, and was again examined by Moore, Alexander Sprunt, Jr., of the Audubon Society, and me on the next day. It proved to be an immature in the white phase, and stayed about the ponds of Key West for some time, being seen on May 24, August 5 and 23, October 8, 11, and 18. On the 18th of October, a bird in the dark phase, either an immature or molting adult, also was seen at the same location. Again on February 24, 1940, a white individual, possibly the same one formerly seen, was observed near a pond on Key West. Also on June 7 of that year a white bird was noted. On June 25, 1940, the Kramers and Newmans of Philadelphia, enthusiastic bird students, came to my home to get me to see a bird new to them,

which proved to be a Reddish Egret, dark phase, at a nearby pond. These are all of the records of this species about Key West, but it is hoped that further investigation will show it to be on the increase here as well as throughout the state.

Louisiana Heron

Hydranassa tricolor ruficollis (Gosse)

The most abundant member of its family among the lower keys; a permanent resident, nesting on many keys of both refuges, and seen commonly about the ponds and bays of Key West.

On April 11, 1940, on a small key located between Torch and Raccoon Keys, 37 nests were counted by Joe Warren and the writer. One nest contained 4 eggs, 23 contained 3 eggs, 6 contained 2 eggs, 4 contained only one egg each, and 3 nests were empty. Several broken eggs were found on the ground and among the bushes—the work, it is believed, of a fish crow which stayed about the key. This small key we named "Louisiana Key" on account of the abundance of the Louisiana Heron on it. On April 24 of the same year, 18 nests were found on the same key (possibly some were recounted); 17 of these contained 3 eggs each, and 1 nest had only a single egg. Many young were observed here during the summer.

Numbers of Louisiana Herons come to the small ponds about Key West to feed, including both adults and young; 25 to 30 were often seen at one time.

Little Blue Heron

Florida caerulea caerulea (Linnaeus)

A permanent resident in the keys and fairly common, although it cannot be classed as abundant. Recorded from Noname Key to the Marquesas. As many as 30 were seen on Sugarloaf Key on February 16, 1940.

Nests with eggs and young were found on Johnston Key on April 10, 1940, and a nest with one young bird on July 23, 1940.

Eastern Green Heron

Butorides virescens virescens (Linnaeus)

A common summer resident. A few winter in the keys, which makes it hard to determine dates of arrival and departure of the

migrants. Rather solitary in habits, and rarely seen in groups of more than three or four birds.

Nesting among the keys of the refuge. On May 15, 1940, a nest was located, made of small sticks about 10 feet up in a mangrove tree, containing 3 eggs, on one of the Snipe Keys. On July 2, 1940, a nest containing 1 young bird was found on a small key just off Sugarloaf Key. On July 23, 1940, a nest, made of small sticks, and located in a mangrove tree, contained 2 eggs, on one of the Snipe Keys. While I examined the nest, one of the adults stayed by, emitting notes like escaping steam.

One Green Heron was seen on Scott's Key on January 11, 1940, and one was found dead on the highway on Sugarloaf Key on December 6, 1940.

Black-crowned Night Heron

Nycticorax nycticorax hoactli (Gmelin)

Apparently very scarce among the lower keys. My only record is of one adult and a bird in juvenile plumage on Bill Key near Torch Key on January 8, 1941.

Yellow-crowned Night Heron

Nyctanassa violacea violacea (Linnaeus)

A permanent resident among the keys and an abundant nester on many of them, ranging throughout the area to the Marquesas Keys, which are approximately 20 miles westward from Key West. Immature birds are frequently seen about the docks and piers of the city and are fairly approachable.

Nesting records for 1940 are as follows: April 4, Snipe Keys: 2 nests containing 1 egg each, 6 nests with 2 eggs each, 7 nests containing 3 eggs each, 3 nests new, with no eggs. Most of these nests were very close to the shoreline. April 10, Johnston Keys: 2 nests containing 2 eggs each, 1 with 3 eggs. April 11, on small key between Torch and Raccoon Keys, 2 nests containing 3 eggs each, and on another small key close by 1 nest with 2 eggs. April 12, on small key near Water and Howe Keys: 1 nest containing 4 eggs, 1 with 3 eggs, and 1 holding 2 eggs. On April 25 the small key of the Snipe Key group was again visited with the following results: 1 nest containing 1 young bird and 1 egg; 1 nest with 2 young, almost grown, one of which was just off

the nest; 1 nest holding 3 eggs; 2 nests with 2 eggs each; and 1 containing 2 young. On May 15, the same key was examined: 1 of the nests contained 3 downy young, 2 of them pecking at each other; another nest held 2 young. June 13, Riding Key: 1 nest containing 1 egg, 1 with 1 young bird, almost grown, and another nest with 1 young, almost grown. July 2, on a key just off Sugarloaf, a nest was found that contained 2 young birds.

On July 11, in the Upper Squashes, an immature Yellow-crown was seen swimming toward a small key. This bird was picked up and brought aboard for examination. When released it swam to one of the boat ropes dangling in the water and climbed up on it. We then placed it on the foredeck of the boat, where it appeared very confiding. Released again, it swam toward the key.

Among the 1941 records is a nest of 4 eggs on March 5 and another with 3 eggs on Cottrell Key in the Key West refuge.

An interesting and rather amusing incident was seen on July 5, 1942, at Bergdal's Camp on Boca Chica Key. An immature Yellow-crown, very tame and approachable, was seen standing on the shore and walking around looking for food. It would approach its objective, then stand, its neck swaying from side to side; then suddenly its bill would dart out impaling the prey. Its attention was attracted to two good-sized crabs, but they, seeing the heron, scurried into a hole. The heron stood waiting and watching for some minutes but finally gave up and walked away under the camp house.

Eastern Least Bittern

Ixobrychus exilis exilis (Gmelin)

Strange to say this little bird has evaded my observation with the exception of one adult brought to me by Joe Warren, our patrolman, on April 7, 1941. It had been found near one of the docks of Key West, and appeared unharmed although apparently dazed. It was turned loose, and slowly made away among the grasses and weeds about a pond in the city. On the same day, Charles Thompson saw one near his home in the city.

Wood Ibis

Mycteria americana Linnaeus

Though common in many parts of the State, the only records I have for this area are of two which were seen from a Coast Guard plane on February 26, 1941, off Key Largo. On the next day, one bird was also spotted from the plane in the Cape Sable area.

Eastern Glossy Ibis

Plegadis falcinellus falcinellus (Linnaeus)

On July 27, 1941, an adult was seen beside one of the small ponds on the island of Key West, in the company of several Louisiana and Green Herons. It stood for a time on one leg, then flew on my approach, alighting farther away.

White Ibis

Guara alba (Linnaeus)

Rare among the keys, although at the Marquesas a few birds may occasionally be seen. On December 13, 1939, two birds were observed there, and on July 16, 1940, two were again seen at the same location. An immature individual, probably a wanderer, was noted near the Perky Camp on Sugarloaf Key, October 22, 1940.

Roseate Spoonbill

Ajaia ajaja (Linnaeus)

Since Robert P. Allen of the Audubon Society has reported[5] so admirably on the spoonbill colony near Tavernier, I give here only records of birds seen by me at other localities, mostly at the Marquesas or westernmost keys of the Key West Refuge, and about Key West.

On February 20, 1940, at the Marquesas Keys, one adult spoonbill flew directly over our skiff late in the afternoon. On July 16, the same year, one lit on the marl flat, Marquesas, and commenced feeding but flew on our approach. Later in the day four were

[5]Allen, Robert P. 1943. The Roseate Spoonbill. *National Audubon Society, Research Report*, No. 2.

seen by Joe Warren and the writer off Little Creek, near Eastern Harbor, Marquesas. One of these may have been the single bird seen before. On April 18, 1941, Joe Warren saw six at the Marquesas, and on June 18, the same year, I observed one in flight there.

Nests were not found by us on the Marquesas Keys, although it is believed they may be built there.

On July 25, 1942, one bird, apparently an adult, was seen feeding about a pond or watered area between Roosevelt Boulevard and my home in Key West. It was studied during two periods of the day, and when last seen was flying toward another pond. On subsequent occasions a single spoonbill (possibly the same individual) was seen feeding on the edge of this pond: on August 13, 1942, between 7:00 and 8:00 p. m., within 100 feet of the car from which I was watching; on August 14 at 8:30 p.m., August 15 at 8:00 p.m.; and on August 25 and 29, 1942.

Greater Scaup Duck

Nyroca marila (Linnaeus)

On January 1, 1940, a female was closely observed near the highway off Long Key. Its size and other characteristics convinced me that it was this species. As it was not collected, however, the record is given for what it is worth.

Lesser Scaup Duck

Nyroca affinis (Eyton)

Ducks, with the exception of the mergansers, are scarce among the lower keys, although abundant in the Cape Sable area as well as many other parts of the State during the winter. Scarcity of proper food plants seems to be the chief reason.

The Lesser Scaup is seen occasionally during January and February. On January 15, 1941, twenty were observed on a small pond in Key West, where some of these birds stayed from January 10 until February 13; this number was the greatest recorded. On January 10, 1942, two birds, and on the 20th, three, all males, were in a small pond on the golf course on Stock Island, and a close view was had.

Natives of this area have told me of other locations where

ducks have been found, but visits to those places have been devoid of results.

American Merganser

Mergus merganser americanus Cassin

Though undoubtedly rare in this area, eight birds of this species were identifed by W. L. McAtee and the writer on December 23, 1941, near Eagle Nest Key in the Great White Heron Refuge. On December 26, 1941, during the Christmas Bird Count, 76 individuals were noted in the waters of the refuge off Key West.

Red-breasted Merganser

Mergus serrator Linnaeus

A winter resident in this area and the only duck commonly found here. It arrives about November 15, and stays through March and occasionally into early April, one bird having been seen on April 8 near the Mud Keys.

They are frequently observed about the small ponds of Key West and also just offshore, but the larger flocks are met with farther out in the Gulf waters of the refuge. On January 6, 1940, an estimated 300 to 500 were seen in one flock near Bay Keys. On January 16, 1941, a count of 275 birds in the refuge waters was made. Flocks numbering 100 to 150 were frequently seen.

Turkey Vulture

Cathartes aura septentrionalis Wied

A permanent resident among the keys, and seen along many of the Overseas Highway bridges. Sixty Turkey Vultures were counted over and about Key West on March 14, 1941. They are common at times about some of the keys of the Great White Heron Refuge, but appear to be scarce or absent from those of the Key West Refuge where the islands are scattered and the waters deeper, probably yielding much less food to their liking.

Swallow-tailed Kite

Elanoides forficatus forficatus (Linnaeus)

The only records so far of this magnificent bird were made on Key Largo, just off the mainland of the State. On May 25,

1940, a Swallow-tailed Kite was seen just over the highway there, and one month later, June 25, the same individual or another was seen in almost the same location. On July 21, 1941, two birds were observed between the highway and the Anglers Club. No nest was found, although that key contains trees adapted for kite nesting. Probably the birds seen were hunting and had merely flown down from the mainland.

Sharp-shinned Hawk

Accipiter velox velox (Wilson)

The only definite records are as follows: March 8, 1939, one flying through the bushes near my home in Key West; March 31, 1940, a bird off Sugarloaf Key; and October 12, 1940, a dead Sharp-shin picked up in Key West. The species is doubtless more common during the winter and the migration period than these scanty data indicate.

Cooper's Hawk

Accipiter cooperi (Bonaparte)

Records: September 14, 1939, a bird dashing about near my home in Key West; March 27, 1940, one in Key West; October 17, 1940, a bird about Boca Grande Key in the Key West Refuge; and October 29, 1940, one off Trumbo Island, Key West. Probably more common during the winter and migration season than the above data indicate.

Florida Red-tailed Hawk

Buteo borealis umbrinus Bangs

Apparently very scarce along the keys, my only record being of one flying and soaring in circles over Boca Grande Key of the Key West Refuge on October 7, 1941.

Insular Red-shouldered Hawk

Buteo lineatus extimus Bangs

This form of Red-shouldered Hawk, which differs only slightly from the peninsular Florida form, is a permanent resident of the keys, and fairly common. At times it appears rather sluggish, tame and approachable, differing in this respect from the more northern forms. Sugarloaf and Big Pine Keys are the favorite localities in this area.

Broad-winged Hawk

Buteo platypterus platypterus (Vieillot)

A winter resident and migrant in this area, October 10 to March 5. Fairly common and approachable; one bird (probably the same individual) remained for some time about the Casa Marina Hotel and West Martello Field where it could be closely studied.

Swainson's Hawk

Buteo swainsoni Bonaparte

This western hawk winters almost every year in Key West and along some of the other lower Florida keys. I have observed it in Key West, on Stock Island, and on Sugarloaf and Noname Keys.

Those seen appeared to be of the light phase or possibly intergrades. They were very easily approached, and seemed tame or sluggish. One bird, in the top of a small tree, at the Botanical Garden on Stock Island, would not fly on a close approach until small objects were tossed toward it. At times a bird along the highway will fly from pole to pole in front of an approaching person or vehicle.

Short-tailed Hawk

Buteo brachyurus Vieillot

I have only three records of this rare hawk in the area. On March 16, 1939, two birds in the white phase were seen soaring near Porpoise Key. On January 1, 1940, one individual of the dark phase was observed soaring near Key Largo, once diving for a short distance toward the earth. On October 17, 1940, one bird in the dark phase was seen at Boca Grande Key in the Key West Refuge.

Southern Bald Eagle

Haliaeetus leucocephalus leucocephalus (Linnaeus)

Although not common along the lower keys, a few are occasionally seen—generally single birds, sometimes in pairs; dates of occurrence range from October through March.

Records have been made of Bald Eagles about Key West, Ramrod, Summerland, Saddlebunch, Torch, Snipe, Water, Cudjoe,

Porpoise, Lower Matecumbe, Key Largo, and Middle Torch Keys. No nests were located, although it is stated by natives that eagles nest in the area.

Marsh Hawk

Circus hudsonius (Linnaeus)

A common winter resident and migrant along the keys; first arrival noted October 5, 1940, Key West; last bird seen May 2, 1942, Boca Chica Key.

This hawk has been recorded on almost every key along the highway from Key West to the mainland, on Big Pine and Noname Keys, over many keys of the Great White Heron Refuge, and in the Key West Refuge to the Marquesas. About 18 were seen above Fort Taylor and the Navy Yard in Key West on November 3, 1939.

Although probably considered more beneficial than harmful throughout the country as a whole, it has been observed several times investigating bird-banding traps in Key West. On one occasion a Marsh Hawk was seen to grab a Mourning Dove through the bars of one of these traps, and on another trap in the same banding field a Marsh Hawk was seen plucking feathers from an undetermined bird, rising with the dead bird in its talons on my approach. Probably the concentration of doves and other birds on such a small area as this island makes easy feeding for predatory birds.

Osprey

Pandion haliaetus carolinensis (Gmelin)

A permanent resident along the keys, nesting abundantly throughout the area to the Marquesas. Although the nests are generally near the top of a mangrove, the trees are short and the nests consequently close to the water, so that they may easily be investigated. Bird students and ornithologists visiting this area have been delighted with such close-up views, so seldom obtainable of nests in most northern localities.

The nesting season commences in November, during which month several nests containing fresh linings of leaves, seaweed, and grasses have been found. Egg laying and the raising of young birds continue through April and probably well into May, as a nest containing one egg was found on Bay Keys on April 22; this was empty on May 21. Several nests containing young birds

have been found in December. Thus the Osprey, like a number of other species, in this latitude has its chief breeding and nesting season during the winter months, much earlier than is characteristic of the same species farther north.

Two nesting sites unusual for this area were on a platform at the top of a tower on Blake Key, near the Snipe Keys of the Great White Heron Refuge, and on the upper part of a light beacon, just below the light, at Northwest Channel off Key West. The nest in the latter situation was composed of sticks, sponge, seaweed, rags, etc., and had been recently used when it was examined on February 18, 1942.

On September 2, 1942, when I arrived at my office in the Post Office Building in Key West I found a box containing an Osprey under my desk. The night watchman stated that it was found in the court of the building; it had apparently struck a wire during a storm. It was later released near one of the docks and flew rapidly away.

Duck Hawk

Falco peregrinus anatum Bonaparte

A fairly common winter resident. The earliest arrival from the north noted was a bird seen September 14, 1941, on Sugarloaf Key; the latest date on which the species was seen was March 22, 1939, a single individual on Bay Keys.

In the Great White Heron Refuge the Duck Hawk has been noted about Bay, Big Crane, Snipe, and Little Pine Keys, and in the Key West Refuge on Boca Grande Key. Along the Overseas Highway it has been recorded on Boca Chica, Sugarloaf, and Big Pine Keys. Several are seen in Key West every winter.

On one occasion a peregrine was seen standing in the grass and weeds in a field near the Casa Marina Hotel in Key West, apparently looking for food. On another occasion one was observed in rapid flight, chasing shore birds near the salt ponds on Key West Island.

A Duck Hawk was seen near the Atlantic side of Boca Chica Key flying rapidly toward a flock of Black Skimmers, toward which it dived, but missed a kill.

In spite of the predatory habits of this bird, its every action creates a feeling of admiration and sometimes of awe, its fear-

lessness and boldness in attack adding greatly to the pleasure of bird study. After all it must eat to live, even if sometimes at the expense of some of our most charming birds.

Eastern Pigeon Hawk

Falco columbarius columbarius Linnaeus

A fairly common winter resident, seen on dates ranging from September 23 to May 2. It has been noted in the Great White Heron Refuge near Scott's Key and off Trumbo Island, and in the Key West Refuge at Boca Grande Key. In addition birds have been seen in Key West and to the east about Boca Chica Key.

Although Pigeon Hawks are at times approachable, this is the exception rather than the rule. On April 23, 1940, one was closely observed on the ground and then on top of a nearby pole. Its markings appeared to be most nearly those of the western form, *F. c. bendirei,* which was recorded on the Tortugas Keys April 8, 1890, and on Key West October 27, 1896.[6] However, the bird seen by me was not taken so there can be no certainty as to its race.

Eastern Sparrow Hawk

Falco sparverius sparverius Linnaeus

Little Sparrow Hawk

Falco sparverius paulus (Howe and King)

The Sparrow Hawk is by far our most abundant wintering hawk; the earliest date of arrival noted by me was September 25, 1941 (Key West), and the latest date of its stay was April 12, 1942 (Sugarloaf, Boca Chica, and Geigers Keys). Visiting bird students have counted them from the mainland to Key West, and found almost every key along the highway to harbor one or more birds. On December 21, 1939, I counted 24 in Key West proper.

Although the supply of suitable food is limited on the outer keys of the refuges, the Sparrow Hawk was seen on Howe Key of the Great White Heron Refuge and on Boca Grande Key of the Key West Refuge, both containing open areas well adapted to its use.

I have not attempted to differentiate between the two forms of this species, although at times differences in size may be noted

[6]Howell, A. H., *op. cit.*, p. 190.

in the field. Apparently both races are abundant in Key West and along the lower keys during the winter.

Mangrove Clapper Rail

Rallus longirostris insularum Brooks

Apparently a permanent resident, although seldom observed during the winter months. This is probably owing to its secretive nature, as well as to the fact that in winter the birds rarely utter the loud call notes so frequently heard during the rest of the year. Common on almost all of the keys from Key West to Big Pine Key, and on the outer keys to the Marquesas.

Several nests were found. One in Key West, just off the old County Road, was at the base of some mangrove bushes and built up a few inches. It contained 9 eggs on May 26, 1939. The adult female left the nest, and with much cackling feigned injury a few feet from me. This disturbance caused the adult male to appear, but for only a few seconds. While I stood very still by the nest the female walked almost silently about my feet and peered into the nest, on which she settled down. When I started away she left the nest again and appeared to be in a fighting mood, coming toward me.

On May 19, 1941, a nest containing 10 eggs was located on Cudjoe Key just off the highway, in a bunch of grasses by a small pond. This nest was inspected on three more occasions. On May 22 the female came off the nest uttering her cackling notes, and stayed close by as I photographed her and the nest. On May 25 an adult bird (whether male or female was not determined) acted differently; it slipped off quietly, and then jumped or flew toward me or the camera. The 10 eggs were still there, and a few minutes later the adult was back on the nest. On May 27 the nest was empty with broken shells outside; no signs of predators and no birds were found. I believe the eggs hatched out normally.

Young birds, in the black plumage, were observed running about on many occasions, generally with one or both adult birds close by. These young were seen during May, June, July, and August, although on August 12, 1942, those observed were much lighter in color and hard to tell from adults at a distance.

This rail is an excellent swimmer. At times it is very approachable, and since little has been written regarding the species, it would be an interesting subject for additional study.

Piping Plover

Charadrius melodus Ord

A migrant and winter resident, although not common along the lower keys. Recorded dates range from August 24 to February 24; they were generally for single birds or twos and threes, and frequently in company with other shore birds.

Cuban Snowy Plover

Charadrius nivosus tenuirostris (Lawrence)

Although known to breed in Florida, this species appears to be scarce along the keys. Only one bird was seen, on March 8, 1940, beside one of the ponds in Key West.

Semipalmated Plover

Charadrius semipalmatus Bonaparte

This bird winters along the keys in some numbers, flocks of 40 to 50 often being seen. It frequents the keys of both refuges, especially where sandy beaches occur. Migrants arrive during August, although some of those seen were probably nonbreeding birds, which stay about most of the summer. Extreme dates are August 1, 1939, one bird, Key West, and April 25, 1939, eight birds on Boca Chica Key.

Wilson's Plover

Pagolla wilsonia wilsonia (Ord)

Resident along the lower keys, its numbers augmented during the winter by migrants from the north.

The keys having sandy beaches, such as Boca Grande in the Key West Refuge and others from Key West to Big Pine Key, are its favorite haunts. On Boca Grande Key one bird whose tail seemed to be somewhat plucked flew on my approach, striking the water and then swimming to shore almost as well as a duck. Although I did not find any eggs this was probably due to their protective coloration, as pairs of birds at certain spots where I searched were greatly agitated.

Killdeer

Oxyechus vociferus vociferus (Linnaeus)

A winter resident on the lower keys, my records being chiefly for the island of Key West, where it is abundant at times.

Birds from the north commence to arrive in October; an extremely early date is August 31, 1942, when one bird was seen in Key West. They remain well into February, but I have no March dates. On December 21, 1939, about 100 birds in all were noted on a Christmas Bird Census about Key West.

Black-bellied Plover

Squatarola squatarola (Linnaeus)

A common winter resident and migrant, a number of nonbreeding birds staying throughout the summer.

They may be seen from Little Pine Key off Noname Key to the Marquesas Keys in the Key West Refuge. Owing to the numbers of nonbreeding birds, the dates of arrival and departure are hard to determine, but during October an increase in the population is noted, and on June 18, 1941, 10 were seen at the Marquesas Keys. This flock may or may not have been migrants. On October 12, 1940, 50 were counted on the Gulf side of Stock Island near Key West.

These birds are called "Christmas Plovers" by some of the natives.

On one occasion a Black-Bellied Plover, apparently injured and unable to fly, entered the water and swam on our approach, repeating this several times. This was in the Crane Key area.

Ruddy Turnstone

Arenaria interpres morinella (Linnaeus)

A common winter resident and migrant throughout the lower keys, a few nonbreeding birds being seen throughout the summer months. On August 18, 1940, twelve were observed on the Atlantic side of Key West. These may have been arrivals from the north.

Approachable and at times fearless, one of these little birds lit and stayed on our skiff which was tied to the larger boat where

we slept. The turnstone probably spent the night aboard, as long after dark I saw it, by flashlight, settled for the night.

Wilson's Snipe

Capella delicata (Ord)

I have only a few records for this species, as follows: October 30, 1939, one bird about the grassy radio range in Key West; January 9, 1940, one bird, probing, at the same location; and December 27, 1940, two at the same place. This range is a large, generally moist field at the West Martello Tower.

Spotted Sandpiper

Actitis macularia (Linnaeus)

A spring and fall migrant and winter resident which has been recorded during every month except June. Birds from the north generally appear during July; a number remain all winter, and individuals have been recorded as late as May 29 (1940). Garrison Bight, Trumbo, and the docks about Key West are favorite resorts, but Spotted Sandpipers have been seen along the keys from No-name Key to Key West. Boca Grande Key in the Key West Refuge is a good place to find them, its beaches and general terrain being adapted to their needs.

Eastern Willet

Catoptrophorus semipalmatus semipalmatus (Gmelin)

This species, a permanent resident, may be seen along the main highway keys as well as on certain refuge keys as far west as the Marquesas. During migration and winter the population is increased, but it is almost impossible to give correct migration dates. Though the western form, *C. s. inornatus* (Brewster), is also known to be a migrant and winter resident, it is practically indistinguishable in the field from the eastern form, and its status is unknown.

The Gulf side of the Snipe Keys is a favorite place for willets. These birds are locally known as "Christmas Plovers," a name given also to the Black-bellied Plover.

Greater Yellow-legs

Totanus melanoleucus (Gmelin)

A common migrant and winter resident, although nonbreeding birds may be seen throughout the year. The ponds about Key West, Boca Chica Key, Sugarloaf Key, and certain other highway keys are favorite localities. It has been recorded also on Boca Grande Key and the Marquesas Keys of the Key West Refuge.

Lesser Yellow-legs

Totanus flavipes (Gmelin)

A fairly common migrant and winter resident; some birds are seen throughout the year. The ponds about Key West are favorite resorts. Also recorded on Boca Grande Key of the Key West Refuge, as well as along the highway keys. One was heard to utter approximately 50 notes without stopping, then flew and shortly returned to the same pond—a customary habit.

Pectoral Sandpiper

Pisobia melanotos (Vieillot)

Only one record, March 17, 1942, for a single individual at a small pond on the island of Key West. Close and lengthy observations with 8-power glasses were made.

As Howell (*op. cit.*, p. 237) speaks of this species as "an uncommon migrant in spring, common in fall, occurring both on the coasts and in the interior," it may be assumed that future field studies will yield more records for the lower keys.

Least Sandpiper

Pisobia minutilla (Vieillot)

This, the smallest of the sandpipers, is a spring and fall migrant as well as a winter resident among the lower keys. My earliest record is July 22 (1941), my latest April 25 (1939). Rest Beach on Key West, the sandy beaches of Boca Chica Key and Boca Grande Key are favorite locations. Here it mingles with its close relative, the Semipalmated Sandpiper, and at times with the Western Sandpiper, these three giving the bird student puzzling problems in identification.

Red-backed Sandpiper

Pelidna alpina sakhalina (Vieillot)

At the time that the late Arthur H. Howell wrote (*op. cit.*, p. 241) this bird had apparently been unrecorded from Key West, although he mentions two specimens taken by Maynard on the Florida keys, November 15 and 22, 1870, and two or three near Sanibel Light recorded by Nichols on April 9, 1917.

Records are still meager; six near Snipe Keys in the Great White Heron Refuge seen by Harold Peters and me, March 10, 1939; two on Key West, October 31, 1939; six on Key West, January 11, 1942; and one on Boca Chica Key, February 16, 1942.

From these dates we may consider this bird an uncommon winter resident, although future studies may prove it to be more abundant than now appears.

Eastern Dowitcher

Limnodromus griseus griseus (Gmelin)

Long-billed Dowitcher

Limnodromus griseus scolopaceus (Say)

As these subspecies are impossible to tell apart in the field, I have not attempted to separate them in this account. Although both forms are known to occur along the keys, it is believed that the eastern form, *griseus,* is the more common one; collecting of specimens, however, is advisable.

Although the Dowitcher is chiefly a spring and fall migrant and an abundant winter resident, nonbreeding birds are seen throughout the summer; it is found in the Key West area, along the main highway keys, and in both refuges. On July 30, 1940, two individuals were recorded at the Tortugas Keys about 65 miles from Key West.

Stilt Sandpiper

Micropalama himantopus (Bonaparte)

The only record I have for this species is of one individual seen about one of the ponds on Key West, December 10, 1939. Guy Emerson of New York and I made a careful study of it at close range for several minutes.

As specimens have been taken at Key West in former years and the bird is known to be a spring and fall migrant through this area, it is safe to assume that future studies will reveal more of them.

Semipalmated Sandpiper

Ereunetes pusillus (Linnaeus)

Mingling with the flocks of Least and Western Sandpipers, or in bands comprised only of its own kind, this little sandpiper must be closely studied to differentiate it. While possibly not so abundant as the "Least," nevertheless flocks of the "Semipalmated" have been seen from about August 18 to April 25 on sandy beaches about Key West, on the main highway keys, on the Snipe Keys in the Great White Heron Refuge, and on Boca Grande Key of the Key West Refuge.

Western Sandpiper

Ereunetes maurii Cabanis

Definite records of this species, although not so numerous as for the "Semipalmated," show that it winters to some extent about Key West, and on others of the lower Florida keys, arriving from the north about August 18. One individual, probably a nonbreeder, was observed on June 25 (1942) on Boca Chica Key by William Anderson of Orlando and me. I have no spring dates.

Sanderling

Crocethia alba (Pallas)

A fairly common spring and fall migrant and winter resident, arriving from the north about August 18. As about 55 birds were recorded on Boca Chica Key on May 30, 1939, and six were seen on the same key on June 10, 1942, it is believed that nonbreeders remain here to some extent. The island of Key West and Boca Chica Key are favorite haunts, where it mingles with other small shore birds.

Black-necked Stilt

Himantopus mexicanus (Muller)

Records of this species are as follows: July 31, 1939, two birds; August 13, 1942, five; and August 26, 1942, five. All were feeding by ponds in Key West.

Although breeding in a number of locations in the State, no nests have been found along the keys, hence it is believed that the Stilts seen on Key West were fall migrants heading southward.

Herring Gull

Larus argentatus smithsonianus Coues

A winter resident among the lower keys, recorded in every month except June, July, August, and September. October 4, 1940, is the earliest date of arrival noted, the species staying until late in April, although one bird which had become oil-soaked was observed on May 27, 1942.

It is common about the docks, piers, and ponds of Key West, and in many parts of the Great White Heron and Key West Refuges as far west as the Marquesas.

Ring-billed Gull

Larus delawarensis Ord

Not nearly so common as the preceding species although wintering among the lower keys to a limited extent.

Howell (*op. cit.*, p. 258) states "the species has been recorded from Miami, but apparently not from the Florida keys, although it reaches Cuba and Mexico in its migrations." My records include four birds at the submarine base in Key West on February 18, 1939; one on a Calda Channel marker, off Key West, on January 24, 1941; and four included in a Christmas Bird Count for the Key West area, December 26, 1941.

Laughing Gull

Larus atricilla Linnaeus

A permanent resident among the lower keys and the most abundant member of the family, especially during the winter after large numbers arrive from the north. A count of 400 birds off Key West was made on January 21, 1942.

At one time they were known to breed at Key West and on other keys off the mainland, and although I failed to find any nests while stationed in the keys, I believe that they still reproduce somewhere in the area.

Under the heading of the Eastern Brown Pelican I have mentioned a Laughing Gull's riding on the back of a pelican.

Gull-billed Tern

Gelochelidon nilotica aranea (Wilson)

The only record I have of this bird is of one individual seen at a pond in Key West on April 29, 1941. This was studied at close range and under favorable conditions. I was previously familiar with the species, hence there is no doubt as to the identification.

Common Tern

Sterna hirundo hirundo Linnaeus

I have only one record of this species, for Garrison Bight, Key West, November 5, 1939. One bird was definitely identified and others farther off are believed to have been the same.

Eastern Sooty Tern

Sterna fuscata fuscata Linnaeus

Although thousands of these birds nest at the Tortugas, about 65 miles off Key West, my only records are of two that circled about our boat off Bay Keys in the Great White Heron Refuge, June 26, 1941. These were probably wanderers from the Tortugas colony.

Least Tern

Sterna antillarum antillarum (Lesson)

The arrival of this summer resident on the lower Florida keys is one of the best signs of springtime, as the increase in heat in this tropical clime is not nearly so noticeable as farther north.

As the Florida keys swing southwesterly from the mainland, various birds are observed along the upper keys and on the mainland before they are seen on Key West or in the lower keys. April 29 of the years 1941 and 1942 is the earliest date I have for the arrival of this species at Key West. A few birds come at first but their numbers gradually increase and nesting takes place on many of the lower keys. As I have no September record they apparently leave this area during the latter part of August.

Fig. 12.—"The Gannet" (formerly the "Scoter"). Fish and Wildlife Service patrol boat, at the Marquesas, Key West National Wildlife Refuge. C. W. Rosenbury aboard.
Photograph by Earle R. Greene.

Fig. 11.—House said to have been occupied by John James Audubon in 1832. Corner of Whitehead and Greene Streets, Key West, Florida. Photograph by Earle R. Greene.

Three hundred were counted on August 18 near the outer point of Snipe Keys in the Great White Heron Refuge, a number of them being in the winter adult plumage.

Eggs or young have been found on Key West, Stock Island, Sugarloaf Key, and on sandspits off Key West and Sand Key.

The species was very abundant during 1939, 1940, and 1941. However, during the spring and summer of 1942 Least Terns were noticeably lacking from many former choice localities, especially about Key West. This scarcity may have been caused by war activities, including dredging, bombing, and target practice in this area.

Royal Tern

Thalasseus maximus maximus (Boddaert)

Seen all the year along the lower Florida keys and throughout both refuges from Noname Key to the Marquesas, sometimes in groups on the sandy bars and always along the channel markers of the boat runs.

They are a beautiful and conspicuous feature of the bird life of the area. Although I found no eggs, Royal Terns doubtless nest in the region; Howell (*op. cit.*, p. 268) records eggs in the U. S. National Museum from Tortugas.

Caspian Tern

Hydroprogne caspia imperator (Coues)

A winter resident similar in appearance and habits to the Royal Tern, but not nearly so common.

My first date of arrival from the north is October 25, 1940, and the latest date in spring is April 11, 1940.

The greatest number seen at one time was 20 birds observed at the Marquesas Keys, the westerly extremity of the Key West Refuge, December 13, 1939.

Black Tern

Chlidonias nigra surinamensis (Gmelin)

A fall migrant, my earliest record in the Key West area being July 20, 1942, and my latest, September 5, 1939. During this period it becomes common, approximately 300 birds being counted about the Snipe Keys in the Great White Heron Refuge, August

4, 1939, and 250 about Rest Beach on the Atlantic side of Key West, August 20, 1940. Black Terns are also common about Calda Channel and Northwest Channel, on the Gulf side of Key West. Most of the birds seen were in the mottled or changing plumage. I have no spring records.

Black Skimmer

Rynchops nigra nigra Linnaeus

I have only a few records for this interesting species but they seem to be the only ones for the lower keys. All were made in 1940. On January 25, ten were seen along Calda Channel on the Gulf side of Key West. On February 1, about 75 were seen by a pond on the island of Key West. On February 9, about 60 individuals were observed on the Atlantic side of Boca Chica Key, and on March 7 two were noted over Garrison Bight in Key West.

White-crowned Pigeon

Columba leucocephala Linnaeus

This, the "white-headed pigeon" of Audubon, is one of the most interesting birds of the Florida keys, and one which delights the visiting ornithologist, as it only occasionally appears farther north on the mainland.

It was the object of persecution in former days, the nests being rifled and the eggs and young as well as the old birds taken by wreckers, fishermen, and spongers. This practice, as well as regular hunting of them, continued until recent years, but under Federal protection, a decided increase in the numbers of this species has been noted.

Wintering in Cuba and other West Indian islands, the White-crowned Pigeon reaches the lower Florida keys in early or mid-May, my records being for 1939, May 16; and for 1940 and 1941, May 10. Joe Warren, my boatman, recorded 10 at the Marquesas on April 18, 1941. Earl Sycks reported 20 birds on Stock Island adjoining Key West, May 9, 1942.

These Pigeons generally leave for the south during September. By the end of that month only a few remain to spend the winter. One was observed on Stock Island about the Botanical Garden in October, 1941, was reported there during the winter, and seen

in March and April, 1942. A bird observed in Key West, May 2, and 6, 1942 was also probably a wintering bird.

Nesting begins shortly after arrival, the birds using to a great extent the mangrove trees among the outer keys from which they must fly some distance to the main highway keys for food for themselves and their young. They do not do this, of course, where food can be procured nearby. A great many nests have been examined:

1939—June 26: On Riding Key, one of the Sawyer Key group, 1 nest about ten feet up made of small sticks and fairly well constructed containing 2 eggs; 1 nest about 12 feet up holding 2 eggs; 1 nest about 15 feet up with 1 egg (another egg on ground below on the verge of hatching, probably was knocked out of nest by adult bird leaving on our approach); 1 nest about 15 feet up containing 1 young bird, large and well-feathered. Nests were about 50 feet apart and of about the same general construction, of small sticks and better built than nests of mourning doves. July 11: On Wall Key, 5 nests, eggs in all (Warren). July 12: Snipe and Barracouta Keys, 10 nests, 6 small birds and eggs (Warren). July 13: Pigeon Key (in Great White Heron Refuge), 7 nests (Warren). July 14: Johnson Keys, 6 nests with eggs (Warren).

1940—June 13: On Riding Key, 1 nest near edge of key over the water containing 2 eggs. July 2: Hawk Key, 1 nest with 1 egg and 1 young bird. July 10: Big Pine Key Mango, 1 nest holding 2 eggs. July 11: On one key of the Upper Squashes, 1 nest of 2 young birds (Warren), 1 nest with 1 egg (Warren), and 1 with 2 eggs (Malone).

1941—June 26: Bay Keys, 2 nests each containing 2 eggs (Lopez). July 10: Bay Keys, one nest 12 feet up with 1 young bird with pin feathers; 1 nest containing 1 bird, almost grown.

1942—June 26: Bay Keys, 1 nest 14 feet up in mangrove containing 2 eggs (Anderson); July 14, this same nest held 1 immature, almost grown, which came off the nest to tree, then flew. Warren climbed up and reported 1 other small bird on nest. July 16: Hawk Key, 1 nest containing 2 young birds (Warren). Eaglenest Key, 2 nests with 2 young birds each (Warren).

Both male and female adults have been recorded incubating on the nests, which is a well known habit of this family of birds.

Among several favorite feeding areas in the lower keys, one is the Botanical Garden on Stock Island near Key West, where at times hundreds of adult birds gather to fill their crops and fly out to their young among the outer keys or those offshore from the highway keys. Although the so-called "highway keys" (those connected by bridges and the roadway from Key West to the mainland) are actually a chain of islands, a person living in the

keys comes to think of them more as an extension of the mainland than as a part of the true keys, and tends to contrast them with the dozens of mangrove keys farther out from them in the Gulf or Atlantic.

Principal foods obtained by the pigeons in the Botanical Garden are fruits of *Ficus aurea* (wild fig), *Cestrum diurnum* (day jessamine), *Eugenia* (stopper), *Elaphrium simaruba* (gumbo limbo), *Carissa grandiflora* (natal plum), *Malpighia, Sapota achras* (sapodilla), *Coccolobis floridana* (pigeon plum), *Coccolobis uvifera* (sea grape), *Phyllanthus acidus* (star gooseberry), and *Schinus terebinthifolius* (Brazilian pepper). Mr. Duncan, superintendent of the Overseas Highway and long a resident of the keys, states that these birds feed on the berries of the poisonwood *(Metopium toxiferum),* and that people who have eaten their flesh afterward have been badly affected.

On June 21, 1942, between 5:30 and 7:30 p.m., in company with a friend I counted 183 birds, leaving the trees about the Botanical Garden and flying out toward the keys in the Gulf. They were in singles, doubles, and in groups up to about 15 birds. About 41, either some of those that had previously gone out or new birds, or both, were counted coming in from outer keys to the Garden. However, the total count of 183 birds is probably very near the correct number of individuals seen at that time.

It would be hard to determine, even approximately, the number of White-crowned Pigeons occupying the Florida keys during the summer. A few counts, out of many taken on trips, may be of interest: June 27, 1939, 38 birds, Noname to Teakettle Keys; July 9, 1940, 37 from Hawk Key to Noname Key; July 11, 1940, 59 between Noname and Key West; April 18, 1941, 10 at the Marquesas Keys (Joe Warren). With few exceptions White-crowned Pigeons were recorded on every key in the Great White Heron Refuge and along the highway keys adjoining, as well as on several of the keys of the Key West Refuge.

The note of this bird is generally a four-noted "coo," not so soft as that of the Mourning Dove. At times the calls reminded me of some of those of the Barred Owl but were not so penetrating.

As thousands of these birds are shot every winter in Cuba by the natives as well as by visiting sportsmen, the number recorded in the Florida keys is gratifying indeed. They should have the fullest protection.

Eastern Mourning Dove

Zenaidura macroura carolinensis (Linnaeus)

The Mourning Dove is a winter visitant and to some extent a permanent resident on the lower Florida keys, as a few birds may be seen in any month of the year. Two were observed on May 28, 1940, at the Marquesas Keys, the western extremity of the Key West Refuge.

I was unable to find any nests although diligent search was made, but the actions of certain birds observed led me to think that they were nesting.

Migrants from the north generally arrive early in October and become fairly common about Key West during November and December, diminishing in numbers in January and February. By March only a few birds remain. Favorite feeding areas include that part of Key West known as Trumbo Island, and the area about West Martello Tower where Mr. Demeritt has been so successful in banding them for some years and where the writer counted 150 birds on November 20, 1940.

As the Mourning Dove is about the only game bird available to hunters of the keys, shooting on the island of Key West was quite a problem, owing to the growing number of inhabitants and to intensification of hunting in that area because few birds were available to the sportsman farther up the keys. A scarcity of these birds during the winter of 1941-42 was very noticeable. This, coupled with the taking over of much of the island by the Navy, destroying good feeding areas, will probably result in continued scarcity.

A few Mourning Doves have been found on some of the keys of the Great White Heron Refuge, as well as occasionally on the higher and dryer islands of the Key West Refuge as far as the Marquesas.

Eastern White-winged Dove

Melopelia asiatica asiatica (Linnaeus)

On May 19, 1940, I had an excellent opportunity of observing one of these birds at close range—my only record. This was near the Inn on Big Pine Key, the bird being observed on the ground, in flight, and also in one of the trees nearby. Mr. Demeritt, a lifelong resident of Key West and a good bird observer,

tells me that he has found birds of this species occasionally among flocks of Mourning Doves.

Eastern Ground Dove

Columbigallina passerina passerina (Linnaeus)

A permanent resident of the keys, observed several times on Boca Grande Key in the Key West Refuge, although not common among the outer keys of either refuge. Fairly common along the highway keys from Big Pine to Key West.

A nest found June 25, 1939, by Joe Warren and shown to me, was located on the golf course on Stock Island. It was on the ground, composed of grass and straw, and contained 2 eggs.

The local name is "tobacco dove."

Maynard's Cuckoo

Coccyzus minor maynardi Ridgway

This interesting but shy bird is not very common along the lower keys. All of my records except one were made on Sugarloaf Key, about 20 miles northeasterly from Key West, in May, June, and August of 1939, and June and August of 1940. On June 24, 1941, a dead bird, which had apparently been killed by a car on the highway, was examined on Cudjoe Key.

As it is a summer resident and known to breed throughout the area, its secretive habits may account for the paucity of records.

Its notes sound somewhat like those of the Yellow-billed Cuckoo but enough different to be recognized.

Yellow-billed Cuckoo

Coccyzus americanus americanus (Linnaeus)

This summer resident is fairly common on the lower keys, especially on Key West, Stock Island, and Sugarloaf Key, and was recorded several times on Boca Grande Key of the Key West Refuge.

Owing to its secretive habits, it is hardly known to the natives, although it is much more common than the preceding species. No nests have been found by the writer, but immature birds have been seen. My records represent the months of May through September.

Smooth-billed Ani

Crotophaga ani Linnaeus

My first acquaintance with this bird was on July 4, 1939, when one was discovered near my home in Key West. At first glance one might deem it a grackle, but its long tail, slow and somewhat clumsy flight, stubby looking bill, and whining notes soon dispel that idea.

My records are for July and August 1939, August 1940, July 1941, and June and July of 1942, generally of single individuals but of two birds on August 6, 1939, and two on June 26, 1942.

Diligent search was made for a nest but without success, and the bird's comings and goings were a mystery to me.

Its notes are rather musical in tone and not at all like those of a Florida Grackle. At times they are loud and repeated, reminding me somewhat of certain notes of the Willet, and are uttered on the wing as well as when perched. It also has a whining note, as well as another that might be expressed as "whew-whew." They seemed to put up a poor fight against aggression by the grackles. In Cuba they are called "Jew birds," and are very common.

Barn Owl

Tyto alba pratincola (Bonaparte)

All of the records I have for this species are of dead birds, as follows: remains of two by the Overseas Highway on Sugarloaf Key, November 22, 1939, apparently killed by cars while the birds were feeding on or close to the ground; one bird on the highway on Cudjoe Key on December 6, 1940, probably killed by a car; and one on highway near Bird Key Bridge brought to me, February 11, 1942, by Joe Warren. I also had a report of a "monkey-faced owl" found dead on Trumbo Island, a part of Key West. The species is probably more common than is indicated by these records, but escaped notice because of its nocturnal habits.

Chuck-will's-widow

Antrostomus carolinensis (Gmelin)

My records for this species in March, April, and September show it to be a spring and fall migrant in the lower keys. It may winter in the keys, but I have no records.

Birds were seen on Bay Keys of the Great White Heron Refuge in March, 1939 and April, 1942. One individual, apparently a female or young in first winter plumage, was flushed twice in September, 1941 from the ground or a low perch by the side of my home in Key West, the last time uttering two "chuck" notes as it flew away. On September 9, 1941, a dead bird was found on the highway on Boca Chica Key. In September, 1941 as well as September, 1942, Chuck-will's-widows were seen in the dense growth of the Botanical Garden on Stock Island.

EASTERN NIGHTHAWK

Chordeiles minor minor (Forster)

FLORIDA NIGHTHAWK

Chordeiles minor chapmani Coues

CUBAN NIGHTHAWK

Chordeiles minor gundlachii Lawrence

In treating the Nighthawks of the lower Florida keys, three subspecies must be considered. I am listing them together as considerable collecting would be necessary to obtain migration and nesting data for the separate races.

Until June of 1941, when Roger Tory Peterson called my attention to the notes of birds over Key West, I had presumed that the migrating Night-hawks were of the eastern form, *minor,* and the summer resident birds, the Florida form, *chapmani.* He suggested to me the possibility of a West Indian race breeding on the keys. This was verified when two birds collected on Boca Chica Key, August 11, 1942, were identified by John W. Aldrich, biologist of the Fish and Wildlife Service, as *C. m. gundlachii,* one a female in the gray phase and the other an immature male.[7]

The call notes of this Cuban race are different from those of the Eastern and Florida Nighthawks, consisting of three or four notes expressed as "killy kadick" by Cubans living along the keys and also thus stated by James Bond in his "Birds of the West Indies." Although no nests or eggs were found by the

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[7]Greene, Earle, R. 1943. Cuban Nighthawk breeding on the Lower Florida Keys. *The Auk,* 60 (1) :105.

writer, it is believed this is the breeding form of the lower keys, but with the possibility of *chapmani* breeding there also.

Referring to Nighthawks as a group, I have seen no large concentrations. On September 3, 1939, about 21 were counted from Sugarloaf Key to Key West; September 7, 1941, about 21 birds were noted flying over Trumbo Island, a part of Key West, these close together and not feeding and therefore probably were migrants *en route;* August 31, 1942, about 12 birds at the Atlantic Ocean side of Key West, apparently migrants. The spring migration appears poorly determined. April 19, 1942, is my earliest date and September 16, 1941, the latest date recorded.

Chimney Swift

Chaetura pelagica (Linnaeus)

This bird, so abundant during migrations especially, in many parts of the south, appears to shun the Florida keys to a large degree. My only records are of 2 birds on April 20, 1940, 1 the next day, and 1 on April 12, 1942, all at Key West. The Swift apparently does not nest along the keys; possibly the scarcity of chimneys has something to do with this, as Howell (*op. cit.*, p. 301) mentions it as "a locally common summer resident over the greater part of Florida as far south as Homestead," which is on the mainland.

Considerable banding of Swifts has been done within the last few years in many parts of the country, which throws much light on their habits and migration routes. However, more such study is needed to establish more clearly the facts regarding their concentrations and migrations.

Ruby-throated Hummingbird

Archilochus colubris (Linnaeus)

A fairly common spring and fall migrant and a winter resident on the lower keys. My records are for Key West, Stock Island, and Big Pine Key. The earliest date of arrival from the north noted is October 1, 1940, and latest date the species has been seen in spring is May 3, 1940.

Favorite feeding places were about the hibiscus and "turk's cap" in my yard in Key West, and about the flowering shrubs and trees of the Botanical Garden on Stock Island.

Eastern Belted Kingfisher

Megaceryle alcyon alcyon (Linnaeus)

This bird is an abundant winter visitant throughout the lower keys, including both refuges as far west as the Marquesas. An early arrival was noted on August 9, 1942, on a wire by the highway bridge between Stock Island and Boca Chica Key. The latest bird in the spring was noted May 16, 1939, on Boca Chica Key.

Southern Flicker

Colaptes auratus auratus (Linnaeus)

Although I was unable to find this species on the lower keys, records show that in former days it was known as far down as Key West, though rarely. Future work may again reveal its occurrence there. My records are for a bird in Tavernier on Key Largo, June 25, 1940, and another near the same place, October 9, 1941. This key, near the mainland, is large and heavily wooded in spots, providing an ideal area for nesting.

Florida Pileated Woodpecker

Ceophloeus pileatus floridanus (Ridgway)

This bird also has not been recorded by me on the lower Florida keys, but as I have two records from Key Largo, I am including them in this list for the benefit of future workers. On August 27, 1939, I heard a bird calling near the Anglers' Club on Key Largo, and on May 6, 1940, one was distinctly seen flying from the same direction. This may be the most southern record of the species in Florida. A search of this key might reveal one or more nests.

Although the late Arthur H. Howell did not recognize the Florida form as separable from the more northern bird, *C. p. pileatus* (Linnaeus), I employ the name in accordance with my policy of following the AOU checklist.

Red-bellied Woodpecker

Centurus carolinus (Linnaeus)

This is the only member of its family that may be considered fairly common in the lower keys, where it is a permanent resident. My records are for Friends Key off Noname Key, Big Pine,

Sugarloaf, Geigers, Torch, and Boca Chica Keys, Stock Island, and Key West, as well as for the Bay Keys in the Great White Heron Refuge. One nesting hole in use was found on Geigers Key in a dead coconut palm tree about 20 feet from the ground and about 3 feet from the broken off top. Adult birds were seen there a number of times during June, 1942, going in and out of the hole.

Yellow-bellied Sapsucker

Sphyrapicus varius varius (Linnaeus)

Apparently a rather rare winter visitant along the lower keys. My records, all of single birds, are: April 19, 1939, Boca Chica Key; November 1, 1939, Key West; December 1, 1941, Boca Chica Key; December 15, 1941, Key West; and December 26, 1941, Key West.

It is interesting to note that the bird seen in Key West on December 15, was about the trees around the old house on the corner of Whitehead and Greene Streets said to have been occupied by John James Audubon during his visit here.

Eastern Kingbird

Tyrannus tyrannus (Linnaeus)

Although nesting on the mainland, where I have seen young birds with their parents along the Tamiami Trail near Coral Gables, in the keys this species seems to be only a spring and fall migrant. Kingbirds arrive from the south during the latter part of March, my earliest date being a bird on Summerland Key, March 24, 1939. For about a month birds may be seen, my latest date in the spring being April 22, 1940 for two birds in Key West.

For the fall migration, when they are more abundant, my earliest date is August 19, 1940, on which date an Eastern Kingbird in immature plumage was noted in Key West. During the latter part of August and throughout September they were common about Key West, Stock Island, Sugarloaf Key and other choice feeding areas, where flocks of from 20 to 40 were seen. As a rule, they disappeared by the end of September although I recorded one individual on Upper Matecumbe Key, October 9, 1941.

Gray Kingbird

Tyrannus dominicensis dominicensis (Gmelin)

An abundant and typical summer resident along the highway keys and also among those of both the Great White Heron and Key West Refuges, being common as far westwardly as the Marquesas.

Dates of arrival from the south varied from late March to early April, my earliest date being March 22, 1942, when three were noted about the Botanical Garden on Stock Island.

The latest fall date is October 10, 1940, when three were seen on Stock Island.

As many as 32 birds, some appearing to be family groups, were recorded in a few hours from Stock Island to Sugarloaf Key on August 21, 1942.

Nesting records follow: June 24, 1939, a nest at Pirates Cove on Sugarloaf Key, about 15 feet up and near the top of a mangrove tree by the water's edge; actions of the adults denoted the presence of young birds. July 10, 1941, a frail nest, chiefly of seaweed, about 8 feet above high water in a red mangrove, on one of the Bay Keys, containing two young in the pin-feather stage; July 11, 1942, a nest at Pirates Cove on Sugarloaf Key, about 20 feet up at the end of a mangrove branch, very frail and apparently made chiefly of straws, hard to reach so the interior was not examined.

Local names for the Gray Kingbird are "fighter" and "hardhead."

Arkansas Kingbird

Tyrannus verticalis Say

This straggler from the west is of frequent occurrence and may be classed as a regular winter visitant to the Florida keys.

My earliest date of arrival is October 13, 1940, for 4 birds seen in Key West. From 1 to 6 birds have been recorded in Key West in November, December, January, February, and March. April 1, 1939 is the last date for Arkansas Kingbirds in spring. They are frequently in the company of the next species. Key West being the terminus, so to speak, of the keys route, is the final gathering place of a number of such species for the winter.

My records include birds near the Seven Mile Bridge, Cudjoe Key, Key West, and one on Boca Grande Key in the Key West Refuge.

Scissor-tailed Flycatcher

Muscivora forficata (Gmelin)

This is another so-called straggler from the west that is even more common than the Arkansas Kingbird in winter, and is naturally a delightful "find" for visiting bird students.

My earliest date of arrival is October 20, 1940, when one bird was seen near the post office in Key West; the wires along the street there were later found to be a favorite resort for this species, members of which, as a rule, flock together while here.

This species has also been recorded in November, December, January, February, March, April, and early May, my latest record being for May 2, 1942. All of my records are for Key West. On December 19, 1941, 15 birds were counted, most of them about a pasture near Fort Taylor, where it was their custom to congregate to catch the many insects present.

Southern Crested Flycatcher

Myiarchus crinitus crinitus (Linnaeus)

My records of this species are few, as follows: on May 26, 1939, 1 bird seen and heard calling, on Saddlebunch Key; April 4, 1942, 2 birds at Marathon; and April 11, 1942, 1 in Key West.

While specimens are lacking, these records are referred to the southern race instead of to the northern form *boreus*, although that form may also occur during migration. According to Howell in "Florida Bird Life," the northern race breeds in the northwestern portion of the State and the southern race throughout the balance of the mainland. I located no nesting birds on the keys.

Eastern Phoebe

Sayornis phoebe (Latham)

An uncommon winter visitant along the keys. Recorded in November, December, January, and February. Records are for Key Largo on the upper keys, Noname Key, Big Pine Key, Sugarloaf Key, and Key West.

Eastern Wood Pewee

Myiochanes virens (Linnaeus)

A fairly common migrant in spring and fall. Extreme dates in spring are April 12, 1942, and April 23, 1940 and in fall, August 30, 1942 and September 19, 1941. Only one or two were seen at a time. Boca Chica Key, Stock Island, and Key West were the only localities of record.

Tree Swallow

Iridoprocne bicolor (Vieillot)

A fairly common spring and fall migrant along the lower Florida keys, although a few may winter.

Arthur H. Howell (*op. cit.*, p. 328) states that this species is "an abundant winter resident in all but the northwestern part" of Florida. As the Florida keys, however, differ in many respects from the mainland, it is not uncommon to find the birds and their habits quite different.

All of my records for Tree Swallows in the spring are for March, from the 4th through the 25th, and in the fall for November, from the 18th through the 27th. They were seen on Noname Key, Little Torch Key, Boca Chica Key, and Key West.

Bank Swallow

Riparia riparia riparia (Linnaeus)

An uncommon but fairly regular fall migrant and a rare spring migrant; mostly seen singly and in pairs with other swallows. August 24, 1939, is my earliest date of fall arrival, and September 20, 1939, my latest. My only spring record is for April 23, 1940, 1 on Key West.

Rough-winged Swallow

Stelgidopteryx ruficollis serripennis (Audubon)

The only record I have of this species is of one bird at Key West, April 22, 1939. It is apparent that this swallow, so abundant in many parts of the eastern states, shuns the Florida keys.

Barn Swallow

Hirundo erythrogaster Boddaert

This is by far the most abundant swallow along the keys during the spring and fall migrations. There are also some

unusual records for other periods, as the bird has been recorded during every month except January, February, and March.

First arrivals from the south were noted on April 9, 1941, 6 birds at Key West. They are fairly common in May and June. On July 3, 1941, 1 bird was recorded in Key West; 1 was noted by the Bahia Honda Bridge near Big Pine Key on July 21, 1941; and another, July 7, 1942, on Summerland Key. These were probably early fall migrants.

Barn Swallows are common about many of the keys in August, September, October, and November, and I have records of an individual bird on Stock Island, December 1, and 3, 1941. In the Key West Refuge they may be seen about Boca Grande Key and the Marquesas, and occasionally about a few of the keys in the Great White Heron Refuge.

Northern Cliff Swallow

Petrochelidon albifrons albifrons (Rafinesque)

Apparently very rare, as I have only one record for a solitary bird seen about Boca Grande Key in the Key West Refuge on October 16, 1940.

Purple Martin

Progne subis subis (Linnaeus)

Fairly common during the spring migration and more abundant in the fall. On March 27 and 29, 1942, and on April 14 and 19, 1940, birds were seen in Key West.

On July 3, 1941, 2 individuals, apparently immature, were observed perched on wires in Key West, the previous night having been stormy and rainy; on July 19, 1939, one was seen on the upper keys near Tavernier and 2 on Lower Matecumbe Key; on July 20, 1942, 4 were seen flying off Boca Grande Key in the Key West Refuge. As a rule, Martins are common during August and September. I have one date in October, namely, the 7th, 1941, when one was seen at Boca Grande Key in the Key West Refuge.

As Purple Martins are known to breed on the mainland as near as Homestead, Florida, it would not be surprising to find them nesting on some of the lower keys if gourds or boxes were erected to encourage them.

Fish Crow

Corvus ossifragus Wilson

Occasionally seen about some of the keys of the Great White Heron Refuge, as well as about Key West and Stock Island.

On April 11 and 12, 1940, one was noted about a small key between Torch and Raccoon Keys in the refuge and it is believed that the eggshells found on the ground and bushes, apparently of herons, resulted from its depredations. In addition, one was also seen on the 12th about Scott's Key some distance away.

Two birds, and sometimes three, were frequently observed about the Botanical Garden and golf course on Stock Island near Key West. On June 6, 1941, a nest was found which was about 20 feet above ground in a tree by the golf course. Although it was empty on that date, I was told later that it contained 2 eggs about May 15. This species may be considered an uncommon resident.

Florida Wren

Thryothorus ludovicianus miamensis Ridgway

On October 24, 1940, one of these birds was seen, and heard scolding, about a trash pile in the backyard of my home in Key West. It was an agreeable surprise to have a visit from this old acquaintance in what appears to be a "farthest south" record, as Howell (*op. cit.*, p. 351) notes this race as occurring "as far south as Key Largo," which lies just off the mainland of Florida.

Eastern Mockingbird

Mimus polyglottos polyglottos (Linnaeus)

A permanent resident along the lower keys to Key West. Also recorded on Water Key in the Great White Heron Refuge in November, on the Marquesas Keys in December, and on Boca Grande Key in February, these last two localities being in the Key West Refuge. My observations show it to be more common on Key Largo, just off the mainland, than farther south. A nest was examined on Sugarloaf Key on June 4, 1939, which contained 2 eggs.

Catbird

Dumetella carolinensis (Linnaeus)

A winter resident and migrant in the lower keys. I have a record of one bird near Tavernier Creek near Key Largo of the upper keys on October 13, 1941. Two birds on October 26, 1941, in Key West represent the earliest date of arrival there, and two on May 9, 1942, at the Botanical Garden on Stock Island furnish my latest date.

Records taken in Harbor, Bay, and Mud Keys of the Great White Heron Refuge show it to be fairly common among the outer keys during the winter.

Eastern Robin

Turdus migratorius migratorius Linnaeus

Southern Robin

Turdus migratorius achrusterus (Batchelder)

I have not attempted to separate these races in the field. The Robin has apparently been rare in recent years. My records are of 15 birds in the Botanical Garden on Stock Island on February 22, 1939, and of 6 in Key West on January 14, 1940.

Wood Thrush

Hylocichla mustelina (Gmelin)

Apparently a rare migrant. My only records are of one bird near my home in Key West, April 20, 1940, and one, possibly the same individual, at the same location on the 22nd.

Gray-cheeked Thrush

Hylocichla minima aliciae (Baird)

A rare migrant along the lower keys. On May 1, 1939, one was seen on the ground and about low perches near my home in Key West. On May 9, 1941, two were observed in the Botanical Garden on Stock Island. The possibility of their being Bicknell's Thrush, *H. m. minima,* is to be considered.

On May 12, 1941, a dead bird was brought to my home by our patrolman, Joe E. Warren, which he had picked up in Key West. This was identified by Dr. Harry C. Oberholser as *H. m. aliciae.*

Further field work may determine that this thrush is more common than my notes indicate.

Blue-gray Gnatcatcher

Polioptila caerulea caerulea (Linnaeus)

A fairly common migrant and winter visitant, chiefly recorded in the Key West and Stock Island areas, but occasionally seen on some of the keys of the Great White Heron and Key West Refuges, as the Harbor Keys and Big Mullet Key. August 6, 1942, is my earliest record for a fall migrant, and March 21, 1941, is the latest date on which it was seen in the spring.

Loggerhead Shrike

Lanius ludovicianus ludovicianus Linnaeus

Although this bird is common on the mainland of Florida, I have only one record for the lower keys, which was of one individual seen on a wire inside the Naval Aviation Field at Trumbo, Key West, on October 5, 1940.

Key West Vireo

Vireo griseus maynardi Brewster

This is the breeding race of the White-eyed Vireo on the Florida keys and is apparently a permanent resident. As it is very similar to the northern races, *V. g. noveboracensis* and *V. g. griseus*, in appearance and notes, winter and migration records may refer to either form.

My records show this bird to be common on many of the keys and especially about Key West and Stock Island, Boca Chica Key, and Big Pine and Noname Keys.

An empty nest of the Key West Vireo was brought to me by Steve Santana, a Cuban, who found it about 7 feet up in a "gumbo limbo" tree on Stock Island. He calls this bird "spider."

This Vireo is very tuneful, some of its notes reminding one of those of a Catbird, Towhee, Wren, or Chat. It may be heard singing at times even during the winter months.

Yellow-throated Vireo

Vireo flavifrons Vieillot

Apparently a rare migrant along the keys, my only record being of one at the Botanical Garden on Stock Island on March 7, 1942.

Blue-headed Vireo

Vireo solitarius solitarius (Wilson)

I have only one record for this species, a single individual at the Botanical Garden on Stock Island on March 14, 1942.

Black-whiskered Vireo

Vireo calidris barbatulus (Cabanis)

A summer resident along the keys. The earliest date of arrival from the south noted by me was May 9, 1941 and my latest record for the fall, September 4, 1942. The dark "whiskermarks" are discernible at close range and differentiate it from the next species.

This Vireo is common about Stock Island, Big Pine Key, Sugarloaf, and Geigers Key, and was also recorded on Hawk and Bay Keys of the Great White Heron Refuge.

Its song is somewhat similar to that of the Red-eyed Vireo but seems louder and more jerky.

Red-eyed Vireo

Vireo olivaceus (Linnaeus)

My records show this species to be a not very common spring migrant. On April 22, 1940, one was carefully examined through field glasses in the Botanical Garden on Stock Island, and on the next day, April 23, one was observed in a tree in my backyard in Key West.

Black-and-White Warbler

Mniotilta varia (Linnaeus)

A winter resident and migrant along the lower Florida keys, including the Great White Heron and Key West Refuges.

The earliest date of arrival from the north noted by me is July 24, 1940, when two were seen on Boca Grande Key of the Key West Refuge. They are fairly common throughout the winter about Key West, Stock Island, and certain groups of keys offshore. The latest date for one seen in spring was May 22, 1941, when one bird was noted in Key West.

Prothonotary Warbler

Protonotaria citrea (Boddaert)

A fairly common spring and fall migrant.

Birds were recorded on April 9, 1939, and April 9, 1941, in

Key West and on Stock Island, respectively. On August 13, 1942, one was seen on Barracouta Key of the Key West Refuge, and on September 12 and 13, 1942, one bird each day about the Botanical Garden on Stock Island.

Worm-eating Warbler

Helmitheros vermivorus (Gmelin)

Records have so far been made for only the fall migration and at the same location, the Botanical Garden on Stock Island, adjoining Key West. Individuals were noted there on September 26, 1941, and on September 6 and 7, 1942.

Northern Parula Warbler

Compsothlypis americana pusilla (Wilson)

Southern Parula Warbler

Compsothlypis americana americana (Linnaeus)

The Parula Warbler is a common spring and fall migrant and a rare winter resident along the lower keys. Separation of the races in the field is impracticable, and no specimens were taken.

The earliest record in the fall is August 6, 1941, for one bird seen in Key West. On August 25, one bird, and on August 27, same year, three, were seen at the Botanical Garden on Stock Island. This shows a fairly early migration for that year, September being the month of greatest abundance. On February 22, 1939, one was observed in the Botanical Garden, Stock Island. May 9, 1942, one bird, Botanical Garden, Stock Island, is my last date of record in the spring.

Almost all of the records are from Key West and Stock Island, but one was seen on the Harbor Keys of the Great White Heron Refuge on March 21, 1941.

Eastern Yellow Warbler

Dendroica aestiva aestiva (Gmelin)

I have two records of this species: April 10, 1939, one bird back of my home in Key West; and September 22, 1942, one in the Botanical Garden on Stock Island. From these meager data this species appears to be a rare spring and fall migrant.

Its great similarity to the Cuban Golden Warbler, which was discovered nesting among the keys, makes these records somewhat

doubtful, and there is also the possibility that sight records made on the keys by earlier observers may have been of Cuban Golden Warblers.

Cuban Golden Warbler

Dendroica petechia gundlachi Baird

In connection with the discovery of this Cuban race in the Great White Heron Refuge, and the subsequent finding of a nest and the collecting of both male and female adult birds, credit is hereby given to Roger Tory Peterson of the National Audubon Society, who was with me on June 15, 1941, when a male bird in full song was discovered on one of the Bay Keys. As the bird, which came very close to our heads, appeared somewhat different from the Eastern Yellow Warbler, and as the song seemed slightly different, Peterson believed it might be a Cuban race.

On June 26 at the same location a bird came within three feet of my head, so that distinct markings were seen. On the 28th a male, a female, and a nest containing one egg were discovered on the same key, the nest being in the top of a red mangrove about 15 feet from the ground. This nest was made of feathers and seaweed. On July 10 the egg appeared to have been broken; it was thought this was the work of a Red-winged Blackbird living on that key, although possibly there was some other cause.

On July 16th a male (probably the same individual) was collected on a nearby key of the same group. On July 30th a female was collected on this same key.

Both of these birds were identified by Dr. John W. Aldrich of the Fish and Wildlife Service in Washington as the Cuban race, *Dendroica petechia gundlachi,* and are the first of this species recorded in the United States.[8]

On June 26, 1942, a male and female were observed, and on July 14 an adult female was seen on the Bay Keys. On August 6, 1942, a male and a female, as well as an immature bird being fed by an adult, were found on Big Mullet Key in the Key West Refuge, several miles from the Bay Keys.

Letters received from Mrs. Frances Hames in July and August, 1943, state that she saw one bird, in song, on one of the Bay Keys

[8]Greene, Earle R. 1942. Golden Warbler nesting in Lower Florida Keys. *The Auk,* 59 (1) : 114.

on May 30, 1943. I consider it, therefore, a regular nester among the lower Florida keys.

Magnolia Warbler

Dendroica magnolia (Wilson)

Records for this species show it to be a rare spring and fall migrant; they are as follows: April 22, 1940, one adult male, in the Botanical Garden on Stock Island, which adjoins the island of Key West; and September 22, 1941, one bird near my home in Key West.

Cape May Warbler

Dendroica tigrina (Gmelin)

Although Arthur H. Howell (*op. cit.*, p. 396) lists this bird, with definite records, as abundant in spring and fall, my own records are only for the spring migration in April and May, during which months it is abundant along the lower keys. The earliest date of arrival from the south is April 18, 1942, and the latest bird seen was observed May 21, 1942. The majority of the records are from Key West and Stock Island, with a few for the Bay Keys in the Great White Heron Refuge.

Black-throated Blue Warbler

Dendroica caerulescens caerulescens (Gmelin)

A spring and fall migrant, and one of the most abundant of its family. Although found to some extent on the outer keys off Key West, most of these birds were seen about the Botanical Garden on Stock Island, where they fed about the many tropical trees and plants of that area, and were exceedingly tame. Possibly the flight from their winter home to the keys weakened them, as they were very approachable.

Extreme dates for the spring migration are April 18, 1942 and May 10, 1941, and for the fall, August 26, 1941 and October 3, 1941.

Cairn's Warbler, *D. c. cairnsi* Coues, is also known to be a migrant along the keys; but as records are few, and the two races are impossible to differentiate in the field, all the birds seen have been referred to *D. c. caerulescens*.

Myrtle Warbler

Denedroica coronata coronata (Linnaeus)

A winter resident along the lower keys and probably a migrant in spring and fall; not common, however, at any time.

All my records were made during the months of January, February, March, and April, the latest being April 1, 1941 for two birds in Key West. One was recorded in Great White Heron Refuge on Bay Key on March 22, 1939.

Black-throated Green Warbler

Dendroica virens virens (Gmelin)

Apparently an uncommon spring and fall migrant. My records are as follows: April 4, 1939, an adult male on Big Pine Key; October 30, 1939, two birds, an adult male and a female or immature, Key West; April 14, 1940, an adult male, Key West; November 5, 1941, one bird on Bay Key of the Great White Heron Refuge.

As Wayne's Warbler, *D. v. waynei* Bangs, is very similar in appearance and its migration route poorly known, it will take collecting to differentiate between these races on the keys and to determine definitely which race, or if both, are found on the keys. It is probably impossible to tell them apart in the field.

Blackburnian Warbler

Dendroica fusca (Müller)

There is only one record of this species, a male in fall plumage, seen at the Botanical Garden on Stock Island on September 7, 1942. On this basis this species must be classed as a rare fall migrant, though the probability exists that it also migrates through the area in spring.

Yellow-throated Warbler

Dendroica dominica dominica (Linnaeus)

A winter resident and migrant on the keys which is fairly common at times. The fall migration begins early, as a bird was recorded July 24, 1940, on Boca Grande Key of the Key West Refuge, and three were seen on Bay Keys of the Great White

Heron Refuge July 30, 1941. The latest date recorded in the spring is April 3, 1942 for one bird in Key West.

Individuals were seen also on Cottrell and Big Mullet Keys of the Key West Refuge, and on Snipe Keys, Bill Key off Torch Key, Little Crane Key, and Harbor Keys of the Great White Heron Refuge, as well as on Big Pine Key, Stock Island, and Key West.

Black-poll Warbler

Dendroica striata (Forster)

An abundant spring migrant, all records for which are in April and May. The first date of arrival recorded is April 23, 1940, and the latest date in the migration noted is May 18, 1941. Almost all of the observations were made in Key West and on Stock Island adjoining.

During the last of April and first part of May of 1941, Key West was full of small birds, chiefly warblers, which apparently were concentrated there by rainy or stormy weather. Many appeared weakened by their flight and were quite tame, allowing approach to within a few feet. The most noticeable were Black-throated Blue Warblers, Black-poll Warblers, Oven-birds, Maryland Yellow-throats, and Redstarts. Several grassy spots were almost covered by feeding Black-polls.

Northern Prairie Warbler

Dendroica discolor discolor (Vieillot)

Florida Prairie Warbler

Dendroica discolor collinsi Bailey

The northern race is considered a migrant in spring and fall, and the Florida bird a permanent resident. Migration dates therefore are doubtful, but the species is represented throughout the year.

Birds were seen from Big Pine to Key West on the main keys and on certain keys of the Great White Heron Refuge, such as the Snipe Keys, Harbor Keys, Howe Key, and the Bay Keys.

Western Palm Warbler

Dendroica palmarum palmarum (Gmelin)

A common migrant in spring and fall and a winter resident. The earliest record of arrivals from the north is September 18,

1941, for about 11 birds in Key West and on Stock Island. The latest date in the spring is May 9, 1941, for two birds at the Botanical Garden on Stock Island.

Oven-bird
Seiurus aurocapillus (Linnaeus)

A common spring and fall migrant and winter resident along the lower keys. The earliest date of arrival from the north is August 26, 1941, for one seen in the Botanical Garden on Stock Island. I have also other late August dates. The last birds noted in the spring were on Boca Grande Key in the Key West Refuge on May 12, 1939, when two were seen. In season Oven-birds are common about Key West and Stock Island, and have been recorded on the Bay Keys in the Great White Heron Refuge.

Northern Water-thrush
Seiurus noveboracensis noveboracensis (Gmelin)

Grinnell's Water-thrush
Seiurus noveboracensis notabilis Ridgway

As these races are almost indistinguishable in the field and no specimens were collected, it is thought best to include them under one heading. On August 26, 1941, one bird was recorded on Boca Chica Key, yielding my earliest date of arrival from the north. The latest date recorded in spring is May 24, 1942, for one bird on Stock Island. Other records include March, April, and May. A bird which Dr. Arthur Allen and I saw on December 30, 1940, on the Snipe Keys in the Great White Heron Refuge, seemed to be referable to *S. n. noveboracensis*. Localities in which Water-thrushes were seen include the Bay and Mud Keys in the Great White Heron Refuge.

Louisiana Water-thrush
Seiurus motacilla (Vieillot)

An uncommon spring and fall migrant, most of the birds being seen at the Botanical Garden on Stock Island. On August 25, 1941, one bird was observed there and another or the same individual on the 29th; on August 16, 1942, one more was seen. Spring records are for single birds at the same place, on March 25 and April 28, 1942. One of this species was recorded on January 15, 1942, on Crane Key of the Great White Heron Refuge.

KENTUCKY WARBLER

Oporornis formosus (Wilson)

The only record I have of this bird is of one which appeared by my front porch in Key West on August 24, 1941. This bird must have been migrating southward.

CONNECTICUT WARBLER

Oporornis agilis (Wilson)

On May 9, 1941, one bird, a male, was seen walking on the ground, later flying up into a bush, at the Botanical Garden on Stock Island. This is my only record.

NORTHERN YELLOW-THROAT

Geothlypis trichas brachidactyla (Swainson)

MARYLAND YELLOW-THROAT

Geothlyphis trichas trichas (Linnaeus)

FLORIDA YELLOW-THROAT

Geothlypis trichas ignota Chapman

ATHENS YELLOW-THROAT

Geothlypis trichas typhicola Burleigh

Identifying these races in the field without collecting, especially during migration, is an impossibility. As a species, Yellow-throats appear about Key West in late September, my earliest date being September 20, 1942. I have only one record of a wintering bird, that of one in Key West on January 21, 1940, which was very tame and approachable, as it clambered about automobiles, a bicycle, etc., within a few feet of people passing on Duval Street in the heart of town.

The earliest arrival noted in spring was on April 7, 1942, when a male was seen on the Bay Keys, Great White Heron Refuge. Common during April and May. The latest date in spring is for one bird, a male, on the Bay Keys, May 21, 1942. No Yellow-throats are resident on the keys.

Hooded Warbler

Wilsonia citrina (Boddaert)

I have only one record of this bird, a migrant male from the north, which appeared on September 19, 1941, in a tree in my front yard in Key West.

American Redstart

Setophaga ruticilla (Linnaeus)

An abundant spring and fall migrant, a few wintering. Earliest dates of arrival from the north are August 6, 1941 and 1942. By the end of September all except a few wintering individuals have left, as September 28, 1941, is my latest record; three birds were seen on this date at the Botanical Garden on Stock Island.

First arrivals from the south observed in the spring were two birds on Bay Key of the Great White Heron Refuge on April 7, 1942. The latest date of one seen in the spring is May 24, 1942, for a bird at the Botanical Garden on Stock Island. One bird observed on Bay Key on December 26, 1941, was probably wintering.

Although chiefly seen about Key West and along the highway keys, Red-starts were noted on Boca Grande and Big Mullet Keys of the Key West Refuge and on Bay Keys of the Great White Heron Refuge.

During the last of April and the early part of May, 1941, thousands of these birds and other warblers were apparently forced down on the lower keys by storms. Yards, roads, and the highway were filled with them, some going into barrooms, a bakery, storerooms, and dwellings. They appeared weak or tame. Some found dead on the highways were probably too weak to avoid oncoming cars.

English Sparrow

Passer domesticus domesticus (Linnaeus)

Although Arthur H. Howell (*op. cit.*, p. 423) states that this introduced species is found in all Florida cities and towns as far south as Homestead, it has now extended its range to Key West, where I found it to be a permanent resident although not abundant. It nested about buildings along Division Street, and was found

also about the lighthouse, the LaConcha Hotel, and a few other spots.

Bobolink

Dolichonyx oryzivorus (Linnaeus)

An abundant spring migrant, all my records being made at that season, although Howell (*op. cit.*, p. 424) states that it is also common during the fall. Birds were seen at Key West, Stock Island, Sugarloaf Key, Big Pine Key, and Key Largo. The earliest spring date is April 22, 1940, for Stock Island, and the latest, May 30, 1941, for Key West.

Maynard's Red-wing

Agelaius phoeniceus floridanus Maynard

This race, known to inhabit the extreme lower portion of the Florida mainland and the keys, is a permanent resident. It is common along the highway keys and on a number of the keys of the Great White Heron and Key West Refuges, having been found on Little Pine Key and westwardly to the Marquesas Keys.

A nest found on Saddlebunch Key May 30, 1939, contained one young bird, just hatched, and part of an eggshell. On July 24, 1942, a nest found on Boca Chica Key in a mangrove bush about 6 feet up held 1 egg.

Orchard Oriole

Icterus spurius (Linnaeus)

A fairly common spring migrant along the lower keys having been observed on Key West and on Stock Island adjoining. I have no fall records. The earliest date is April 9, 1939 and 1941, and the latest, April 22, 1940, so it is apparent that their stay is a short one.

Florida Grackle

Quiscalus quiscula aglaeus Baird

Although this subspecies is presumed to be a permanent resident along the Florida keys, my records indicate that it is absent from September to February, inclusive. Speculating as to where it winters, as it is found on the mainland during those months, it is thought possible that the birds from the keys join those farther north on the mainland.

Large flocks can be seen about Key West in March, and the birds are common there and along the keys through August. A nest was examined, July 10, 1940, on a small key on the Atlantic side of Bahia Honda Bridge. It was made of mud and grasses, about 5 feet above the ground in a small bush, and contained 4 eggs.

A "sandbox" tree, standing in the courtyard of the Key West postoffice, has long been a favorite nesting place and a number of nests are annually built among its branches. The custodian of the building is kept busy during the season looking after young that fall to the ground, to the great concern of their parents. A "Spanish laurel" tree on Simonton Street is another preferred nesting site; this tree is one of the finest of its kind in the area.

Eastern Cowbird

Molothrus ater ater (Boddaert)

Apparently uncommon or casual along the lower keys. I have only two records: April 7 and 14, 1942 (probably the same individual on both dates), a male bird, on one of the Bay Keys in the Great White Heron Refuge.

Scarlet Tanager

Piranga erythromelas Vieillot

One record only, an adult male bird in Key West on April 27, 1940.

Summer Tanager

Piranga rubra rubra (Linnaeus)

One record, a male bird, at the Botanical Garden on Stock Island on September 22, 1942.

Florida Cardinal

Richmondena cardinalis floridana (Ridgway)

The Cardinal is and has long been a favorite cage bird with the Cuban population of the lower keys. Trapping and caging has reduced the wild birds greatly in number, but their fecundity has kept them from being entirely extirpated. If proper protection could be given this would be one of the common birds of the area.

There are a few Cardinals about Key West, more about the

Botanical Garden on Stock Island (a favorite nesting location), and their numbers appear to increase northwardly on the more wooded keys. They are found also on Little Pine Key, Mud Keys, and on the Bay Keys of the Great White Heron Refuge. Here, as elsewhere, the Cardinal is a permanent resident.

Eastern Blue Grosbeak

Guiraca caerulea caerulea (Linnaeus)

One record: On April 21, 1940, one bird, a male, was seen in bushes near my home in Key West.

Indigo Bunting

Passerina cyanea (Linnaeus)

Apparently an uncommon spring migrant along the keys. My records are as follows: April 22, 1940, a male on Stock Island and another male in Key West; May 3, 1940, 2 males on Stock Island; May 7, 1940, a male on Stock Island; April 30, 1941, a male near my home in Key West; and April 12, 1942, a male at Pirates Cove on Sugarloaf Key.

Painted Bunting

Passerina ciris (Linnaeus)

This beautiful little bird has suffered to an alarming degree from trapping and caging, practiced over many years by the Cuban population of the keys. The Cubans love birds, but their admiration expresses itself in wishing to cage them to have about their homes and dwellings and stores. The writer found that breaking up this practice was a delicate and difficult matter, and one that required considerable public education.

My records are chiefly for March, April, and May, during the spring migration. However, I have one record for the bird on February 5, 1942, in Key West. I cannot state that Painted Buntings are common along the keys except for a few days during this migration. They are apparently more common on the mainland.

Eastern Savannah Sparrow

Passerculus sandwichensis savanna (Wilson)

A rather rare winter resident along the lower keys. My records, all for 1942, are: January 20, one on Stock Island; January 27, one bird, possibly the same individual, Stock Island; March 4, one in Key West.

Eastern Grasshopper Sparrow

Ammodramus savannarum australis Maynard

On May 1, 1941, Mr. F. Wenckebach of Key West brought me a specimen he had found dead on Roosevelt Boulevard in Key West. Dr. Harry C. Oberholser of the Fish and Wildlife Service in Washington identified it as this subspecies.

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ATOMIC ENERGY

A. A. Bless
University of Florida

1. The Atom

This year we are celebrating the fiftieth anniversary of the discovery of X-rays. There is another fiftieth anniversary which is, perhaps, just as important, namely, the discovery of the electron and the beginning of atomic physics.

Until 1895 the atom was considered to be a sphere of invariable composition. The atom of oxygen, for example, was assumed to be a sphere with every part having the same composition, and the composition of one atom being totally different from that of any other atom. The universe of matter was assumed to consist of 92 distinct building blocks or elements. In 1895, J. J. Thompson and other workers discovered that all materials contain negatively charged particles, electrons. If matter contains negative charges, it must also contain an equal number of positive charges, since matter in its ordinary state is electrically neutral. The elementary units of matter, the atoms, must therefore have a structure consisting of an equal number of positively and negatively charged particles. The manner in which these particles must be arranged so as to provide the observed stability of atoms is a whole story in itself, and we cannot go into it now. The picture of the present day atom evolved slowly, but by the end of the first quarter of this century, the picture was fairly clear. The atom is assumed to have a positively charged nucleus situated at its center and negative charges, electrons, whirling around at various distances from the nucleus. Fig. 1. The number of charges on the nucleus of any element turned out to be equal to the order number of the element in the periodic table. Thus, hydrogen had one positive charge on its nucleus; helium, two; lithium, three; boron, four; etc. The number of electrons outside the nucleus was naturally equal to the number of positive charges on the nucleus, since the atom in its usual state is neutral, as mentioned before.

Regardless of what was done to the electrons, the nature of the element did not change. Electrons could be expelled from a given atom, and then the atom would be in an ionized state, but it would still remain the same atom. It did not exist long in this state of ionization and very soon acquired a number of electrons equal to the positive charge on the nucleus.

The disturbance of the electrons creates light rays, ultraviolet rays or X-rays, depending on the number of the electrons and their closeness to the nucleus. The configuration of the electrons is also responsible for the chemical and physical properties of the material.

In the last analysis all these properties depend on the number of positive charges on the nucleus. So long as the number of positive charges on the nucleus remains the same, the number of electrons and their configuration remains the same, so that the chemical properties, as well as the radiations emitted by the atom when disturbed, remain essentially the same. In order to change the chemical properties, or to change the nature of the radiation, the number of positive charges on the nucleus must be changed, which in turn changes the number of electrons outside the nucleus and their configuration.

Fig. 1—The atom consists of a positively charged nucleus with negative electrons moving around it. The nucleus contains most of the mass of the atom.

The size of the nucleus and of the electron is of the order of about 10^{-12} cm in diameter, which is extremely small compared to the size of the atom, the latter having a diameter of about 10^{-8} cm. The distance, for example, between the nucleus of the hydrogen atom and its electron is 10,000 times as great as the size of either the nucleus or the electron. The space occupied by these particles is thus an infinitesimal fraction of the total space occupied by the atoms. This fact has a great deal to do with the utilization of atomic energy.

2. The Nucleus

As mentioned before, the nucleus contains a number of positive charges equal to the order number (or the atomic number, as it is

sometimes called) of the element in the periodic table. Each positive charge is associated with a mass equal to the mass of the nucleus of the hydrogen atom. The atom of sodium, for example, the eleventh element of the periodic table, contains eleven hydrogen nuclei, or protons, as they are often called. However, the atomic weight of the element is 23. This means that the element must have 23 units of mass on the basis of oxygen having 16 units. This also means that the nucleus of the sodium atom must contain approximately 23 times as many mass units as a proton. Since it already has 11 protons, it needs, therefore, 12 more mass units which have no charge on them. These mass units are called neutrons. Each atom, therefore, contains as many protons as is equal to its atomic number, and enough neutrons to complete its atomic weight. So long as an atom has a given number of protons, it will possess certain definite chemical and physical properties, regardless of the number of neutrons it possesses. For example, the element of sodium may have 12 neutrons or 13 neutrons, its atomic weight being consequently either 23 or 24. (Substances which have the same number of nuclear charges but different weights are called isotopes). However, so long as the number of positive charges remains the same, all physical properties of the element, with the exception of its mass, remain essentially the same. Similarly, the hydrogen atom has a nucleus consisting of one proton; deuterium or heavy hydrogen has a nucleus consisting of a proton and a neutron. While the mass of the deuterium nucleus is thus double that of the light hydrogen, the properties of heavy hydrogen remain essentially the same as those of light hydrogen, since it contains only one positive charge.

The nucleus (and the atom as well) is completely specified by the number of positive charges and the number of mass units it contains. It is customary to place the number of charges in the lower left and the number of mass units in upper right of the chemical symbol of the element. For example, sodium with 11 charges and 23 mass units is represented as $_{11}Na^{23}$; its heavier isotopes as $_{11}Na^{24}$. The light and the heavy hydrogen are respectively $_1H^1$, $_1H^2$. The notation $_6C^{12}$ stands for carbon with 6 units of charge and 12 mass units. $_0n^1$ is the nuclear symbol for the neutron since it contains no positive charges and has one mass unit.

3. Radioactivity: Transmutation of Elements.

While most of the atoms are very stable, many, particularly among the heavy ones, are not. Becquerel, in 1896, found that uranium atoms eject alpha, beta, and gamma rays. The alpha rays turned out to be nuclei of helium atoms, (symbol: $_2He^4$), while the beta rays are high speed electrons; the gamma rays are merely short wave X-rays, emitted presumably because of the excitation of the atom. The process of ejection of particles from the nucleus is called radioactivity. The ejection of a negative charge moves the element up one place in the periodic table, since the number of positive charges on the nucleus then increases; while the ejection of positive charges lowers the place of the element in the periodic table.

The lowering or the raising of the number of positive charges on the nucleus and thus the changing of one element into another

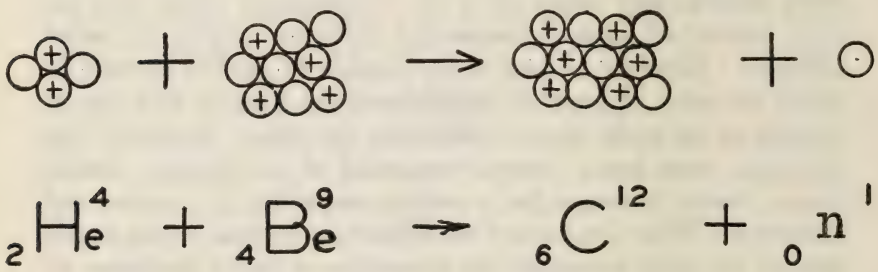

Fig. 2—Pictorial representation of the formation of carbon out of berillium. Neutrons are represented by blank circles, while protons are circles with a plus sign.

may be accomplished by a number of agents: ultra short gamma rays, or high speed particles such as electrons, alpha particles, neutrons, protons, heavy hydrogen atoms, etc. An illustration of such a process is the change by the aid of fast alpha particles of the beryllium atom into carbon with the ejection of a neutron. The reaction can be represented thus: (Fig. 2): $_2He^4 + {}_4Be^9 \rightarrow {}_6C^{12} + {}_0n^1 + E$.

In this reaction we use the same principle of balancing as in an ordinary chemical reaction. The number of charges of the product and also the number or mass particles in the product must be equal to the number of charges and mass particles in the reactants. The number of positive charges of He and Be (6) is equal to that of C.

Similarly, the number of mass units of the reactants (13) is equal to the number of mass units of the product (12+1). In most nuclear reactions some of the particles move with great speed and thus have large kinetic energy. The term E represents the excess kinetic energy of the product over that of the reactants. More will be said about E later. It sometimes happens that the bombardment of an atom by means of particles results in the formation of an element of a lower atomic number. This occurs when the number of positive charges emitted in the process by the new element is greater than the number of positive charges it receives from bombardment.

Transmutation of elements thus became a reality. The old dream of the alchemist was realized, when man was able to make gold out of baser elements. This transmutation was accomplished, however, not by the aid of the "philosopher's stone," but by the aid of more realistic devices such as cyclotrons, Van de Graaff machines, etc. These devices give to particles, such as heavy hydrogen, the high speeds necessary to break through or into the nucleus. The process of formation of gold out of mercury by these means is much too expensive to be commercially profitable. However, some substances formed in this way are worth much more than gold. In this class belong the so-called man-made radioactive substances.

4. Tracer Elements

Occasionally the material resulting from bombardment is not stable; it is emitting particles and rays similar to those of naturally radioactive substances. Such substances were thus termed artificially radioactive. These man-made radioactive substances are just as effective in the treatment of diseases as the naturally radioactive substances, and can be more cheaply produced. Moreover, many of them proved to be of extreme value in biological investigations. Some substances are absolutely essential for the well-being of plants or animals, even though the amount of that substance taken in by the organism is too small to be measured by chemical means. However, if these substances are made radioactive, it is possible, by means of special detectors, to trace the progress of the element in the digestive system of the animal, and thus study directly the effects of the element on the various portions of the digestive system. Sodium, for example, is made radioactive by bombardment with heavy hydrogen. The radioactive atoms fed to animals or plants will betray their progress in the digestive system through the rays that they are emitting. These rays are detected

by special devices, so-called Geiger counters, the operation of which we cannot discuss here.

5. Uranium Fission

The process of artificial transmutation was so well developed during the last decade that practically every element in the periodic table was made artificially. Many scientists were intrigued by the probability of being able to form new elements beyond the uranium atom, the last or heaviest element known, by bombarding uranium. While some evidence was obtained that the bombardment of uranium yielded transuranic atoms, there was also evidence of an entirely new kind. It was found that some of the products of the bombardment of uranium, instead of differing from uranium by very few units in mass or in charge, actually differed from the uranium atom by a great deal. In other words, evidence was discovered that uranium was split into two fragments of nearly equal size, such as $_{56}$Ba and $_{36}$Kr; $_{55}$La and $_{31}$Rb; $_{54}$Xe and $_{38}$ Sr; $_{53}$I and $_{39}$Y; $_{52}$Te and $_{40}$Z. In most cases the elements so formed are unstable isotopes of the common stable elements. This was the first time that splitting (or fission as it is often called) of an atom was accomplished. Also, in common with other nuclear reactions, the products of disintegration had a great deal of kinetic energy; they were moving with tremendous speeds. These speeds were equivalent to those of electrons acted on by 200,000,000 volts, or to the average speed of particles at a temperature of a trillion degrees.

6. Matter Energy

In order to understand the origin of this kinetic energy, we must go back to a principle of equivalence of mass and energy which was given by Einstein in 1905 in connection with his theory of relativity. Einstein at that time showed from theoretical considerations that a given mass, m, corresponds to an amount of energy given by the relation $E=mc^2$. For example, one gram of mass or of matter is equivalent to an amount of energy equal to 9×10^{20} ergs or 9×10^{13} joules. This relation was verified in a great variety of ways.

It is important to understand the distinction between chemical energy and this matter energy. In the case of chemical energy, resulting, for example, from the combustion of 1 gram of coal or gasoline, the total mass of the products of combustion is equal to the mass with which the reaction was started. One gram of coal, upon combustion, yields approximately 10,000 calories. This energy is released entirely at the expense of the configuration of the elec-

trons. Matter, so far as is now known, takes no part in this reaction. On the other hand, when matter is transformed into energy in accordance with the relation $E=mc^2$, the matter itself disappears. All of the energy is at the expense of the material, none of which is left. The amount of energy given off by one gram of matter in this kind of reaction is about a billion times as great as the amount of energy given off at the expense of electron configuration. The difference in the quantity of energy developed by the two processes may be understood from this example: the complete combustion of a pound of coal and the complete utilization of all of the energy of combustion would raise the battleship Missouri (which weighs 45,000 tons) to a height of about 1.5 inches. On the other hand, the energy realized from the transformation of 1 pound of matter

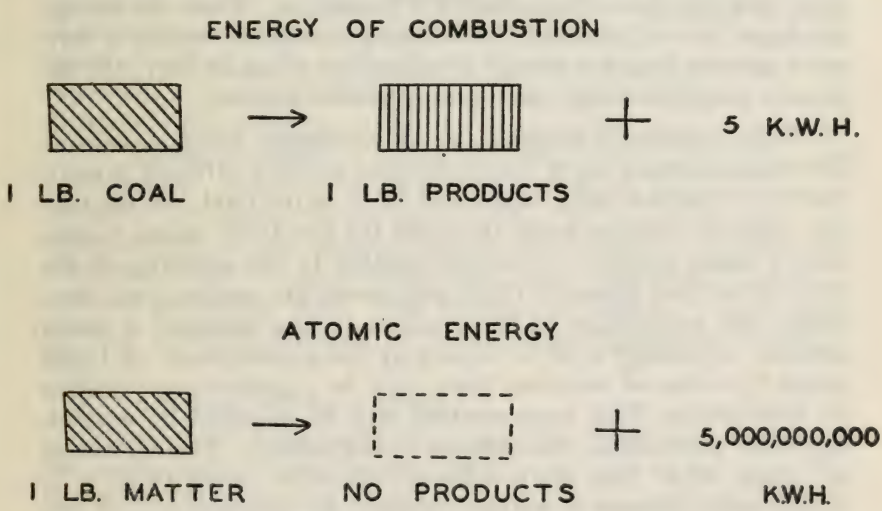

Fig. 3—Comparison of energy of combustion and energy of matter.

would be sufficient to raise the battleship Missouri the total distance from here to the moon. The energy obtained from the disappearance of one pound of matter would provide more than 5 billion kilowatt hours (Fig. 3).

It was found that in the disintegration of uranium, the total mass was slightly (about 0.1%) less than the mass of the reacting elements, and this loss of about 1/1000 of the mass accounts for the high energy observed in the process of fission.

7. U-235 Disintegration Chain. Reaction

After a great deal of study, it was found that the fission process is supplied, not by the common $_{92}U^{238}$, but by an isotope, name-

ly, U-235, or those uranium atoms which have 92 positive charges and only 143 neutrons instead of 146 neutrons possesssed by the normal uranium atom. This U-235, on splitting into fragments, emits also from 1 to 3 neutrons. These neutrons, in turn, are capable of affecting other U-235 atoms, and if, in their flight, they do encounter U-235 atoms, more fission will result with the consequent emission of more energy and ejection of new neutrons, and so on. This was the first time that products of a nuclear reaction were such as to enable the process to go on, and so provide a chain reaction. Since the time it takes for the splitting of the atom and the ejection of new neutrons is extremely short, the energy developed in a very short time is so great that an explosion is bound to result. The speed with which such a reaction proceeds is greater even than the speed with which TNT explodes. Since the energy developed by one pound of U-235 during a nuclear reaction is very much greater than the energy developed by a ton of TNT, the explosive possibilities of this reaction become evident.

While deposits of uranium ore are reasonably common, most of the uranium atoms are of the U-238 type, which is difficult to split, the U-235 fraction being only about 0.7% of the total. In the normal mass of uranium metal there are too few U-235 atoms to provide a chain reaction. Neutrons emitted in the splitting of the first one or two atoms of U-235 may never hit another such atom unless the percentage of these atoms in the material is much greater. If energy is to be utilized by the bombardment of U-235 atoms by means of neutrons, there must be a greater concentration of these atoms. This concentration may be provided by separating these atoms from the common U-238 variety. The separation of atoms when they have different chemical characteristics is fairly easy, because it can be obtained by precipitation of one element from another by utilizing the difference in the combining power of the two elements. However, in the case of the two uranium isotopes, this evidently is impossible because the chemical properties of the two are similar. In their separation, the only property which is different in the two elements, namely, the mass of the atoms, must be utilized.

The separation of isotopes may be made in a great variety of ways. It is known that lighter atoms diffuse more easily through a given porous membrane. After diffusion, the fraction of the lighter element in the mass which has diffused is slightly greater than before diffusion. By making a given quantity of material diffuse a great many times, each time using only the fraction

which passed through the membrane first, each succeeding product has higher concentration of the lighter element than the preceding and in this way the partial separation of U-235 atoms may be accomplished. Another method of separation is by thermal diffusion. This is very similar to diffusion through a porous membrane. The lighter elements possess a slightly higher velocity at a given temperature than a similar fraction of the heavier elements. If the faster portion of the gaseous product is removed and evaporated again, the fraction of the U-235 atoms in each new batch will be higher with each new evaporation than in the preceding.

There is one other difficulty with the utilization of the energy that accompanies the fission of the U-235 atom. The neutrons which are ejected as a result of the fission have too high a speed to produce new products of fission. It is found that slow neutrons are more effective in producing fission of uranium-235; they are captured more easily by the uranium nucleus than the fast neutrons. The problem of slowing the original neutrons ejected in the process of fission is solved by mixing the U-235 atoms with a moderator. A moderator is a substance which does not absorb neutrons, but merely slows them down. It was found that elements of low atomic weight, such as heavy water, graphite and paraffine, make efficient moderators; they slow down neutrons, without capturing them. The chance of neutrons, upon their slowing, of being captured by U-235 atoms, is greatly enhanced. (Fig. 4.).

8. The Critical Size of a Bomb

It was pointed out before that the size of the nucleus and of the electrons is a small fraction of the total size of the atom. If the nucleus is taken as a sphere with a diameter of about 1/4 inch, the atom would be a sphere with a diameter of 200 feet, and this would be the distance between the nuclei of two adjacent atoms. The chance that neutrons emitted by a given atom would strike another atom close to it is extremely small because the nuclei occupy such a small part of the total space. If there is to be a chain reaction, we must provide enough material so that one or two neutrons from each of the disintegrating atoms of uranium are sure to strike another nucleus of U-235. If enough material is provided so that no matter in which directions neutrons are traveling they will hit another nucleus, the chain reaction will proceed. If the amount of material is insufficient, the reaction will stop after one, two, or a few more uranium atoms have been broken up. It follows therefore, that there is a critical size for

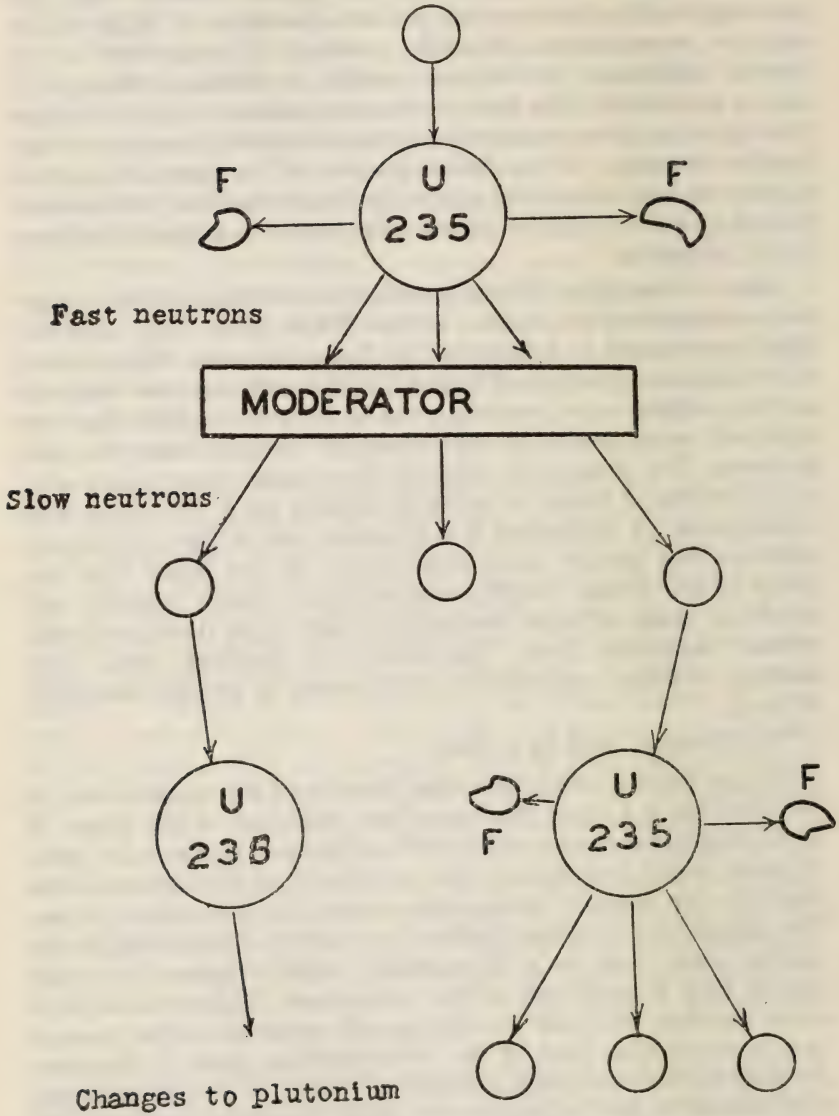

Fig. 4—Formation of Plutonium.

the amount of material that must be used in a chain reaction. If the amount of material used is less than that, the reaction will not proceed; if the amount of material is greater than that, the reaction will proceed with great violence. This shows that it is perfectly safe to store a given quantity of U-235 so long as it is considerably smaller than the critical size. Bringing two or three such safe masses together will give a mass which is greater than the critical size and will allow the chain reaction to take place with the consequent explosion.

9. Neptunium and Plutonium

For a while, U-235 seemed to be the only source of atomic energy. However, very early in the study of fission it was predicted that an element beyond uranium, one whose atomic number (or whose number of positive charges) is 94, would be as susceptible to fission as U-235. The production of such an element is accomplished by the bombardment of U-238 with fast neutrons. The elements resulting from that bombardment are shown by the following reaction:

$$^{238}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{239}_{93}\mathrm{Ne} + {}^{0}_{-1}\mathrm{e} \; ; \quad {}^{239}_{93}\mathrm{Ne} \rightarrow {}^{239}_{94}\mathrm{Pu} + {}^{0}_{-1}\mathrm{e}$$

The first product of the reaction is neptunium. This element, on ejection of a negative charge, becomes plutonium, with an atomic number 94, and an atomic weight 239. Since it is a different element, plutonium has different chemical properties, and its separation from uranium may be accomplished by chemical means.

The probability of formation of plutonium out of U-238 is greatly increased if the neutrons have just the right energy, intermediate between the high energy of neutrons emitted in the process of U-235 fission, and the low energy neutrons, which are most effective in producing fission. The slowing down of neutrons emitted in the fission process must be such that some of them have just the right velocity range for plutonium formation, while others have the right velocity range for U-235 fission, so that the chain process could be continued. The problem was solved satisfactorily, and by the end of the War plutonium was being produced in fairly large quantities. The metal had the predicted properties. (Fig. 4.).

10. Peacetime Uses of Atomic Energy

The process of formation of plutonium out of uranium is very promising from the standpoint of utilization of atomic energy for peaceful purposes. The process, though it involves great evolu-

tion of energy, can be made to take place slowly enough to prevent explosion. In order to keep the process going, a given mass of uranium metal must be enriched with a considerable quantity of U-235 in order to provide the chain reaction. The splitting of U-235 provides neutrons for the formation of plutonium out of U-238, and it also provides neutrons for splitting of other U-235 atoms and for continuing the chain reaction. The process is stopped periodically and the plutonium is removed by chemical means. This metal itself may then be used as the spark plug for the chain process. As we have seen, the disintegration of U-235 creates a great amount of heat. In order to lower the temperature of the whole mass a cooling agent, such as water, must be used. The energy of the hot water can then be utilized without any great difficulty for peaceful purposes.

If the heat energy is to be utilized in engines or similar labor saving devices, the temperature of the reaction must be very high. The high temperature would create serious difficulties in the process of formation of plutonium; however, it is quite likely that such difficulties will be overcome and atomic energy may be used in large stationary installations. On the basis of our present knowledge of atomic energy the probability of using small amounts of such an agent as U-235 to propel planes or other mobile engines is extremely small.

11. Conclusion

The development of our understanding of atomic processes leading to the utilization of matter energy discussed in the preceding pages, does not give the reader any idea concerning the tasks that had to be performed and difficulties that had to be overcome before the final product was obtained. Literally thousands of problems had to be solved, thousands of calculations had to be made in a very short time before the first atomic bomb was allowed to explode in New Mexico. Every step was over untried ground. The official report of the project by Smyth gives only a very faint idea of the magnitude of the task involved. Paraphrasing Churchill one may with justice say that at no period in the history of science has so much been done by so few in so short a time. It will stand as a magnificent scientific achievement.

On the other side of the ledger is the fact that at no time in the history of humanity has a weapon so destructive, so vicious in its possibilities, been let loose on humanity. The explosive force of this weapon defies imagination. But this is not all. The amount of radioactivity involved in the process of explosion and

in the process of disintegration of the atoms is such as has never been witnessed by humanity. The total amount of the radioactive materials in all hospitals in the United States is a fraction of a pound. One thousandth part of a pound of radioactive material such as used in the treatment of cancer, if allowed to spill in a good-sized room would make that room uninhabitable. In the case of the bomb, many pounds of radioactive material are dropped in a relatively small area. The harmful possibilities of such a concentration of radioactivity can only be dimly realized. It is a poison against which no gas masks are of any avail. The duration of the radioactivity is not yet fully known, but certainly it is much longer than any lethal gas that has ever been invented.

Needless to say, scientists are aware of the terrible effects of this weapon. As a consequence, they are taking greater interest in the social aspects of our national and international life. This is indicated by the stand that scientific societies are now taking with reference to questions of international organization. If, as a result of the atomic bomb, the scientists of the world will exert greater influence on social affairs and bring to the solution of these questions the qualities of objectivity, understanding, and intellectual honesty which are the prime prerequisites for all scientific discovery and the same qualities which have enabled scientists to create this bomb, the dropping of the bomb will have been a blessing to this world. If, on the other hand, the solution of all social problems is left in the same hands that have guided the world in the past, that have brought so much misery and pain, the addition of the atomic energy may well be the last straw needed to finish off this world.

THE ESTABLISHMENT OF MUSSOLINI'S NEO-FASCIST STATE

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For more than eighteen months after the surrender of Italy in September of 1943, Benito Mussolini served as Adolf Hitler's quisling in the Nazi occupied areas of the Peninsula. The spectacle of the erstwhile Sawdust Caesar cravenly accepting crumbs from the hands of his former protegé quite naturally aroused derision throughout Italy and the entire world. Yet this phenomenon went deeper and bore graver implications for the history of the country than might appear at first hand. It is the purpose of this paper to show how Mussolini was set up as Hitler's Italian puppet, and to indicate the importance of that development.

One distinction should be drawn at the outset. The revival of Fascism came about as a necessary alliance between two divergent viewpoints. To the Germans, it was a mere incident in their effort to use Italy for the immediate and limited purpose of war. To Italian reactionaries, it was the logical outcome of the Fascist experience, 1922-43.

* * *

When on September 8, 1943, General Dwight D. Eisenhower announced Italy's capitulation, the German government was forced to decide between risking a hasty occupation of the kingdom or allowing Italy to be taken over by the Anglo-Americans. Once the military occupation was determined, the Nazis had the choice of governing the overrun territories in their own name or by means of puppets. The task facing an army of occupation is to rule with the least possible trouble and the fewest possible soldiers. A collaborationist regime will relieve the conqueror of tedious and time-consuming administrative detail. In the case of Italy, such a government might rally certain blocs of public opinion to the assistance of the Nazis and prevent some military units and equipment from falling into the hands of the Allies. Thus it was that, although after the collapse of his original partner the Fuehrer spoke of Italy as having been a "liability" to the Reich, at the same time he sponsored the organization of a Fascist quisling dictatorship.

The first indication that the Germans intended to set up a puppet government in the Italian areas under their control came

over the Nazi Zeesen radio station early on September 9, barely twenty-four hours after the Eisenhower broadcast. The German radio spoke of the formation in Italy of "a National Fascist government speaking in the name of Mussolini," and called for Fascist volunteers to enroll immediately for the purpose of resurrecting the Party and committing acts of sabotage against the Allied forces. Soldiers and airmen were ordered to destroy all installations, to refuse to give up their arms; railway workers were told to cease operating the trains. That this reanimated Fascist government existed in name only was patent, for the first proclamation of the new regime did not even mention a single minister of state or other official connected with it beside Mussolini. The broadcast, preceded by the playing of the Fascist anthem *Giovinezza,* stressed particularly that "the Badoglio betrayal will not be perpetrated," that all turncoats would be punished, and that the revivified Fascism (called by the Allies "neo-Fascism") would be concerned with fundamental social reform.

The days following September 9 were used by the Germans to extend and consolidate their control of central and northern Italy. The cities of Milan, Turin, Verona, and Bologna were scenes of much disorder. Bitter clashes between German and Italian troops and between Germans and partisans were reported for almost a fortnight before opposition was reduced and the patriots disarmed. The chaos made the distribution of food difficult and bread riots were common. The capital city of Rome quickly fell to the Nazis with King Victor Emmanuel and Premier Pietro Badoglio barely making their escape.

Except for periodic promises that the Republican Fascist government's composition would be announced shortly, little was known definitely, but it was believed that some sort of cabinet of collaboration was impending. Weight was added to this opinion by a German announcement of the 10th that the Badoglio regime no longer existed. Meanwhile, Allied newspapers speculated whether Roberto Farinacci, one of the more rabid Fascists, might not be selected as the Italian quisling. Mussolini was still held as prisoner by Badoglio and, even if rescued, no one knew whether he would consent to serve under the Germans. One newspaper recounted the alleged statement to his barber that the Duce made after his arrest, "You must know that I always was and (always) will remain a good Italian." The paper added, "Many Italians doubt whether Mussolini is ready to accept the planned collaboration."

Lacking though information might be about a Republican Fascist government, the German methods of domination were those which had been time-tested in the other occupied countries. Martial law was proclaimed and local governmental authorities were made responsible for the behavior of the populace in their districts. The German military divided occupied Italy into two zones, north and south, except for Rome which had a separate administration.

By virtue of an agreement concluded at 4:00 p.m., September 10, between the Nazis and the Italians, control over the Eternal City was to be exercised through an Italian commandant, Division General Count Giorgio Carlo Calvi di Bergolo. The arrangement provided that German soldiers were to remain outside Rome, an open city, except for guards at the telephone exchange, the German embassy, and the EIAR radio transmitter.

This armistice was violated almost before the ink of the signatures was dry. Lorries of German soldiers rolled into the metropolis, the principal points were placed under guard, and sentries were stationed at the approaches to Vatican City. The purpose of the pact, apparently, was to make it possible for the Germans to hand orders to Calvi di Bergolo to be reissued in his own name. This would avoid having all prohibitions blamed on the Nazi command. To the north, similar arrangements were made by General Vittorio Ruggero for the surrender of the Milan area. The situation was stated quite concisely by the National Fascist radio, broadcasting via Berlin, on September 20. After denying a rumor that Pope Pius XII had refused to receive the commander of the southern military zone, Field Marshal Albert Kesselring, the Fascist radio declared, "Kesselring can be denied nothing."

It was thought expedient by the Germans to allow the formation at Rome of a giunta of career bureaucrats to carry on the technical and administrative functions of the various ministries in the absence of a national government. Accordingly, four days after the surrender of Rome, a series of such nominations was published. These new officials were called commissaries and received no salaries. None of the appointees was a former ranking Fascist.[1]

[1]A former prefect, Dr. Gian Giacomo Bellazzi, was named president of the council of ministers; Dr. Augusto Rosso, onetime ambassador to Washington, became commissary for foreign affairs; Dr. Lorenzo LaVia, ex-prefect of Bergamo, headed the interior ministry. Others picked by Calvi di Bergolo were: Dr. Enrica Cerulli, Italian Africa; Dr. Giovanni Novelli, grace and justice; Dr. Ettore Cambi, finance; Dr. Giuseppe

In the meantime, the possibility of the formation in Italy of a national regime along Fascist lines had been given substance by a Trans-ocean flash, on the evening of September 12, that Nazi paratroops and men of the Waffen S.S. and Secret Security Service had just rescued Mussolini from confinement in the mountainous Gran Sasso area northeast of Rome. Several former associates as well as his family were said to be with him. On arrival in the Reich, the Duce was alleged to have telephoned his thanks to Hitler and then retired to rest. The German radio and press chortled over the escape and promised that Mussolini would soon place himself at the head of things in occupied Italy.

Mussolini, presumably at Munich, spent the days immediately following his liberation in resting and catching up on the events which had taken place since July 25, for the Badoglio jailers had kept him cut off from all news sources. While Fascist hierarchs who had escaped the Allies were conferring with Mussolini to select a capital for the new government on Italian soil, the German and Japanese foreign offices found time to state categorically:

> "The Government of the Empire of Japan and the Government of the Greater German Reich jointly and solemnly declare: the treachery of Marshal Badoglio's Government in no way affects the three power pact which remains in force without any change. The Government of the Japanese Empire and the Government of Greater Germany are determined, jointly, with all the measures at their disposal, to carry on the war to a victorious conclusion."

Later a Wilhelmstrasse spokesman added: "Let it be understood that the National Fascist government, which has the support of all militant sections of the Italian people, is determined to carry on the war at the side of its allies." It was advertised that many Blackshirt and some infantry divisions in Greece and Jugoslavia were taking up arms again in support of Mussolini.

The first proclamations of the National Fascist government took the form of five orders of the day published over Mussolini's name on September 15. These decrees announced: (a) Mussolini's assumption of the supreme direction of Fascism, (b) his appointment of Alessandro Pavolini as temporary secretary of the Na-

Giustini, education; Professor Vittorio Ronchi, agriculture; Luigi Velani, communcations; Dr. Ernesto Santoro, industry and commerce; Paolo Saltino, public works; Dr. Amedeo Tosti, popular culture; Dr. Francesco Cremonese, foreign currency and exchange; and Dr. Franco Liguori, war production. At least two of these men, Rosso and Tosti, had held places briefly under the Badoglio government. Three days later, September 17, commissaries for the military ministries were chosen: General Rino Gambelli, war; Vice Admiral Emilio Farrari, marine; and General Pilot Aldo Urbani, air.

tional Fascist Party (henceforth to be known as the "Republican Fascist Party"), (c) restoration of all former Fascist office-holders to their old positions, and (d) appeals to the people to collaborate with the Germans, fight the Anglo-Americans, reform the Fascist militia, and punish traitors. All Italian soldiers or ex-soldiers were ordered on the same day to report to the nearest German commandant. Shortly thereafter, Lieutenant-general Renato Ricci was named commander-in-chief of the Voluntary Militia for National Security.

Several more days elapsed with little indication that the government was anything more than a radio invention of the Nazis. Except for a D.N.B. broadcast reporting that Mussolini had released all army officers from their oaths to Victor Emmanuel, events lagged. Even Mussolini's whereabouts was not publicly known. The business of government was carried on only at the provincial and communal levels.

Mussolini's first radio address after his liberation was made from Germany on September 18. His voice sounded old and tired. Omitted were the histrionics of the past. Such odd phrases as "the radio does not permit long speeches" made the speech seem weak. The Duce told of his escape from confinement, then urged his people to war against the Allies. He outlined a four point program for faithful Fascists: (a) the taking up of weapons again at the side of Germany and Japan, (b) the reconstruction of the army with the Fascist militia as nucleus, (c) the elimination of the traitors of July, and (d) "the establishment of a social basis on which the State may be erected, supported by the work of its citizens." Interesting was this emphasis on social reform: "the State we wish to establish anew shall be national and social, in the best sense of the word, a Fascist state as it was at its beginning."

World reaction to Mussolini's comments came quickly. Prime Minister Churchill seemed to express prevailing Allied feeling when he said to Parliament:

> "The escape of Mussolini to Germany, his rescue by paratroops, and his attempts to form a quisling Government which with German bayonets will try to refix the Fascist yoke on the necks of the Italian people raise, of course, the issue of Italian civil war. It is necessary in the general interests, as well as in that of Italy, that all surviving forces of Italian national life should be rallied around their lawful Government and that the King and Marshal Badoglio should be supported by whatever liberal and leftwing elements are capable of making head against the Fascist-quisling combination and thus of creating conditions which will help to drive this villainous combination from Italian soil, or better still, annihilating it on the spot."

The *Diario Comercial* of Tegucigalpa, Honduras, echoed this with a reference to Mussolini as an "exploded skyrocket."

After his radio speech, Mussolini visited Hitler and then departed on the 21st for Italy. Two days later came the listing of the slate of neo-Fascist cabinet ministers. Mussolini was chief of government and foreign minister. Marshal Rodolfo Graziani, out of favor since 1941, received the portfolio of defense. Guido Buffarini, who supported Mussolini during the Badoglio palatine revolution in July, was named interior minister.[2]

In order to give a picture of an Italy with a centralized Fascist government, broadcasts of the Republican Fascist radio reported great activity by the new regime: Fascist prefects were said to be functioning in the principal cities of occupied Italy; the Fascist Party had been reformed at Genoa; the new prefect of the Trentino was ordering the pictures of Mussolini to be put back in the place of honor in all government offices; a new currency tied to the Reichsmark was announced to be in the process of preparation; and a commission was appointed in Rome to examine the attitude adopted by members of the Fascist party during the July crisis.

One of the most surprising actions of the National Fascist government was the broadcasting of attacks on the Vatican. This was totally out of keeping with Fascism's previous program, for down to 1943 efforts had been made to maintain satisfactory relations with the papacy. September 20, at 6:30 p.m., the National Fascist radio, broadcasting via Berlin, aired an anti-clerical statement written in the style of Roberto Farinacci:

> "The Vatican, with its preaching of pacifism and with its anti-German sentiments, has disturbed the Catholic conscience of the Fascist fighters. These centers of sabotage and betrayal will be eliminated from the new Fascist and Republican Italy. Let not the policy of the Vatican force us to have recourse to radical measures. . . . the Catholic Church has had many favors from the Mussolini regime. . . . to this. . . . the Catholic Church replied with direct and indirect sabotage of the Fascist war, of the racial campaign and of Fascist ethics. . . . If it were true—and it is not—that there exists an incompatibility between the Catholic faith and

[2]Domenico Giampietro Pellegrini, former treasury undersecretary, became minister of finance; Antonio Tringali-Casanova, Fascist leader who had supported Mussolini on July 25, was chosen minister of grace and justice; Carlo Biggini received the portfolio of education; Fernando Mezzasoma, popular culture; Giuseppe Peverelli, public works; Edoardo Moroni, agriculture; Silvio Gai, corporative economy; and Domenico Arcidiacono, communications. Francesco Maria Barracu was selected under-secretary to the premier.

> the Fascist faith, and if we are forced to choose between the Catholic faith and the Fascist faith, we by the side of our German comrades, would choose the Fascist faith."

Whether or not the Germans were using the Fascist radio to say unofficially what they were hesitant about saying openly, the fact remains that they failed to follow up the original charges against the Church. On the very next day the Nazi Transocean news agency denounced as "pure invention" the Reuters' report of the radio attack on the Vatican. A Wilhelmstrasse spokesman was quoted as saying that neither the German nor the Fascist Republican government knew of any such broadcast. A second, though less hostile, denunciation came on the 25th when the Fascist radio complained about Italian ecclesiastics who were opposed to Fascism. Nor was the Vatican alone in bearing Fascist wrath. Jews, freemasons, traitorous generals, industrialists, leftists, and anti-Fascists were condemned along with the priests.

To reassure skeptical Italians, the neo-Fascist press and radio gave little play to stories which might bring unfavorable reactions. The Fascists did say, though, on September 19, that Italian militiamen would be organized and sent to the Russian front to erase the defeats sustained by the Italian expeditionary force in the Don Bend at the beginning of 1943.

The capital of the Republican Fascist state was located at Verona, on the excuse that telegraphic communication with the rest of Axis Europe would be better there than in Rome. The Eternal City was also regarded as being "too near the sea." By the end of September, most of the new ministers had been installed in office at Verona.

Mussolini felt obliged at this time to make another public statement calling on former Fascist legionaries to follow his lead:

> "Legionaries! Once more the Duce calls you. Now it is a question of life or death. Legionaries of Africa, Spain, Russia, the Duce knows you will gather around him. It is better to meet a glorious end on the battlefield than to live as traitors. Legionaries! He who fears death is unworthy to live!"

On the basis of reports from Switzerland, the attempts of the Fascists to mobilize the militia proved futile. In most places not one man in ten answered the call. In Domodossola, a town of 6,500 inhabitants, only thirteen men appeared. The rest of the able-bodied men went into hiding to escape mobilization.

Mussolini's efforts to obtain diplomatic recognition abroad succeeded but slowly. Germany, Roumania, Bulgaria, Croatia, and Slovakia granted quick recognition. The Japanese let it be

known that appropriate steps would be taken when official reports had been received from the Japanese ambassador to Italy and after consultation with the German government. To speed up recognition from the Nipponese, the Duce saluted the third anniversary of the Tripartite Pact, September 27, saying that he deemed it a good sign that his return to Italy coincided with the anniversary of the Pact, and pledging to maintain that alliance and wipe out the humiliation of Italy's collapse.

The Hungarians gave grudging recognition "at Germany's request," on the 29th. It was alleged that in a stormy five-hour cabinet meeting the Budapest government decided to maintain relations with Marshal Badoglio. Two hours after the publication of this news, a strong note from Berlin brought an about face and Mussolini was recognized. Several days later the puppet government of Burma followed suit, then ultimately Spain and Japan. Finland flatly refused to recognize the neo-Fascists.

The first cabinet session took place on September 27. The government promised to summon a constituent assembly in due course to draw up a constitution for the state. It was apparently decided that in propaganda the emphasis should be laid on presenting the regime to the Italians as a genuine government of the people. While the use of the term democracy was carefully avoided in all official statements, every effort was made to view the changes anticipated as a return to primitive Fascist principles. Hence the newspaper *Il Messaggero* wrote, "With the disappearance of the monarchy, the road is clear for the abolition of all remaining privileges." For home consumption, stories were spread that Sicily was to be detached from Italy and turned into a British strategic base, that thousands of Italians were being deported to Africa and Russia, and that the Barclay Bank was engaged in exploitation in Sicily.

As an aftermath of the first cabinet meeting, a decree of October 2 created special tribunals to try for high treason party members "guilty of passing to the enemy at the moment of trial." This was followed by mass arrests of persons who manifested joy when the Fascists fell from power. These included senators, diplomats, army officers, prominent administrators, newspaper men, and ex-Fascists. Roberto Farinacci and Alessandro Pavolini particularly promised arrest of all traitors without clemency.

Marshal Graziani was the most active of the cabinet ministers during the early days of the neo-Fascist government. He held meetings at Rome and elsewhere of army officers and tried to get them to serve the Mussolini cause once again.

While Graziani was rebuilding the army, the Germans were begging for workers from Italy for their factories and recruits for their armies. Marshal Kesselring appealed in person over the Rome radio on September 29 for men. He promised that the enlistees would receive the same pay as German soldiers and, after a period of training in special camps, enjoy the same rights as their Nazi friends.

The impressment of workers into the ranks of foreign laborers in Germany was carried on by the neo-Fascists. The Mussolini government called for the migration of workers from southern and central Italy to the northern part of the country, promising work and decent living conditions; no hint was made that the workers might be transported to the Reich. A clue to what awaited the laborers was contained in the threat that criminal activity would be countered by summary action under the Germans' inexorable laws.

The indication that the new National Fascist state was a functioning entity came with the publication of the oath of allegiance to the puppet government. Whether anyone could support the new regime is equivocal; certainly there must have been many mental reservations among the neo-Fascist bureaucrats and army officers who promised: "I swear to serve and defend the Italian Social Republic, its institutions and laws, its honor and territory in peace and in war, if necessary at the cost of the extreme sacrifice. I swear it before God and those who gave their lives for the unity, independence and future of the Fatherland."

* * *

So far, this paper has dwelt on the technical process by which Mussolini returned to power. Now it remains to evaluate the results of this temporary rebirth of Fascism. These results may be divided into two categories, short and long term. Of the immediate consequences, the following should be pointed out: (a) First of all, the Fascist renascence rallied some diehard Blackshirt troops to the German cause. These soldiers became available either for combat duty or for guarding military installations behind the front lines. Also, valuable equipment, including some naval units, was prevented from passing to the Allies. (b) The Italian defection had been a mighty blow both to Nazi prestige and the whole philosophy of dictatorship. The reappearance of Mussolini helped the Axis to recover face. At the same time it made possible the propaganda line that the majority of Italians rejected the surrender brought about through the treachery of King Victor Emmanuel and Marshal Badoglio. (c) The neo-

Fascists performed routine administrative functions and kept to a minimum the numbers of Nazi personnel required to rule the country. A whole generation of Italians knew no other form of government than Mussolini's. It was easier to control such people by reconstructing the old order than by outright martial law. Also, jobs were created for deserving Fascists who had been ousted from their posts by the Badoglio coup d'état. This helped to keep them from drifting toward the Allied camp. (d) On the principle that most Italians would rather receive unpleasant directives from other Italians than from Germans, the Nazis used Mussolini to recruit workers for Reich factories. (e) By reestablishing the Fascist state, the Germans kept up the fiction of the Fascist partner-in-arms, thus giving them a legal lever for regulating Italians abroad and Italian laborers inside Germany. (f) The Nazis found it to their advantage to use the Fascist press and radio as sounding boards for statements they did not wish to make on their own initiative.

In contrast to the foregoing are the broader achievements of the Germans. (a) The neo-Fascists split Italians into two camps, those favoring Mussolini and the Nazis, and those backing Badoglio and the Allies. (b) The Badoglio people, in summoning Italy to join the Allies, had put much stress on the legitimacy of the monarchy. The Fascists, who countered by espousing republican doctrines, succeeded in stirring up much latent republicanism among Italians in northern Italy. (c) Through radical promises, the revived Fascist political machine tried to discredit in advance any liberal institutions Italy might be given by the democratic parties. If someday it would be possible to compare column by column a workable liberal constitution with a paper charter of radical Fascist reforms, some argument might be made for the latter program. Parenthetically, Mussolini must have hoped that a successful comeback would give him a more impressive niche in history than he had earned previously, hence his willingness to gamble to the last on a German victory.

It remains for the historian to add two other considerations. Because the Fascists punished many of the July traitors, Italian courts later were spared the trouble of having to try these ex-Fascists for war crimes and other offenses. And lastly, the rise of the National Fascists with their attacks on the middle classes and the important industrialists, godparents of the original Fascism, provided a telling argument for the Anglo-Americans. It showed in clear colors how the Fascist hydra came ultimately to devour its very progenitors.

THE PECTIN CONTENT OF THE PERSIAN LIME[1]

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During recent years the production of Persian or Tahiti limes has steadily increased until it has become one of the major industries of south Florida. A portion of each year's crop is now being processed in order to help supply the growing demand for canned fruit juices. Of the 218,693 boxes of Persian limes produced in Florida during the fiscal year ending June 30, 1945, 11,908 boxes were processed. During the months of July and August of this year alone, 28,609 boxes of limes were sent to the canning plant (L. G. MacDowell, *in lit.*, 1945). The lime residue resulting from processing this fruit is, at the present time, being used chiefly as a source of lime oil (L. G. MacDowell, *in lit.*, 1945). Although pectin is extracted commercially from some of the other citrus residues, apparently little information is available on its extraction from the residue of the Persian lime. Adriano and his associates (1932) working with the Philippine-grown Tahiti lime found that the peel of this fruit contains 2.63 percent pectin. The present investigation was undertaken to determine the quantity and grade of pectin which can be extracted from the Persian lime grown in Florida.

MATERIAL AND METHODS

The limes used in this study came from various lots of fruit delivered to a packing house in south Dade County during the 1945 season. Since each of the lots came from different widely scattered groves, they were fairly representative of the limes produced in that area. Each sample consisted of fifty, unwaxed limes selected at random from lots of either ungraded fruit referred to as "field run" or from lots of fruit graded as "Number 3's". The analyses were run as soon as possible after the fruit arrived in the laboratory.

A composite sample of juice was extracted from the fifty limes with an electric reamer, its specific gravity determined, and a 100 ml aliquot transferred to a liter beaker containing 500 ml of distilled water. Another composite sample was made from the peel and rag remaining after the juice had been extracted from each group of fifty limes. Such a sample was composed of small, triangular sections removed at random from each of the 100

[1]This investigation was sponsored by the Science Research Council of the University of Miami.

pieces of peel and rag. After such a composite sample was weighed, it was blended with 300 ml of distilled water in a Waring Blendor, the resulting mixture poured into a liter beaker, and 200 ml of distilled water added. The diluted sample of juice and that of the peel and rag were each adjusted to a pH of 1.45 with 1N HCl and extracted with constant stirring at 70 degrees C. for one hour. Myers and Baker (1931:21-32) have previously demonstrated that these are the optimum temperature and pH conditions for the extraction of pectin from such samples. Due to the relatively high viscosity of the extracts, it was necessary to dilute those of the juice to approximately 900 ml and those of the peel and rag to approximately 1800 ml before attempting to clarify them by filtration. A small amount of Hyflo Supercel was added to each of the diluted extracts before filtering it through a large Buchner funnel containing a previously prepared filter mat. Each filter mat consisted of two sheets of Reeve Angel No. 230 filter paper covered with a thin layer of the Hyflo Supercel. The filtered juice and peel and rag extracts were placed in 1000 ml and 2000 ml volumetric flasks respectively and diluted to volume.

The pectin was determined as true calcium pectate by a method fundamentally the same as the modification of the Carre'-Haynes method described by Hinton (1940). One hundred ml aliquots of the clarified juice extracts and 75 ml aliquots of the clarified peel and rag extracts were used in these determinations.

The pectin used in the determination of the jelly grade was obtained by precipitating this material from 600 ml of the clarified peel and rag extracts with twice that volume of 90% ethyl alcohol containing 5 ml of 1.0 N HCl per liter. The precipitated pectin was removed by filtering the mixture through a piece of fine cotton cloth and squeezing it as free of alcohol as possible. It was then rinsed in two changes of 95% alcohol followed by one of ethyl ether. After the ether had been allowed to evaporate at room temperature, the pectin was dried in a constant temperature oven at 60 degrees C for 16 hours, ground with a mortar and pestle, and returned to the oven for an additional 16 hours at the same temperature. This method is essentially the same as that outlined by Myers and Baker (1931:5). These authors have pointed out that the addition of sufficient HCl to the alcohol used in the precipitation of the pectin obviates the construction of jelly strength-pH curves for the various pectins, since pectins precipitated under these conditions will have hydrogen ion concentrations that will result in the forma-

tion of jellies having the greatest strength (1929:17,41 and 1931:6).

Jelly grade[2] was determined on the basis of a 65% added sugar jelly made by first dissolving 0.5 grams of pectin followed by 50 grams of sugar in 100 ml of distilled water and boiling the mixture until the weight of the contents of the beaker was 77 grams. As soon as this weight was reached, the contents of the beaker was quickly poured into a wide mouth bottle which was immediately stoppered to prevent evaporation. The jellies were allowed to stand at room temperature for 24 hours before jelly grade determinations were made using the apparatus and calibration curve described below.

Various pieces of equipment have been used to determine the strength of jellies. The strength of the jellies here described was determined with a piece of apparatus similar in principle at least to the Lipowitz meter (Tschudy, 1943). The apparatus consists of a vertically supported, sliding rod having the flat surface of a small, metallic hemisphere attached to its lower end and a small balance pan mounted on its upper end (Plate 1). The wide mouth bottles containing the jelly samples were placed under the lower end of the rod in such a manner that the metallic hemisphere rested on the center of the surface of the jelly. Small washers of approximately the same weight were placed on the pan at the rate of one every two seconds until a sufficient weight had been added to cause the hemisphere to break through the surface of the jelly. The total weight supported by the jelly, including the total weight of the washers plus the weight of the apparatus, was converted into jelly grade by reference to a calibration curve (Fig. 1). This curve was constructed by determining the weight supported by 65% added sugar jellies of known jelly grade. These jellies were made by the procedure described above except that various amounts of 150-grade commercial citrus pectin were used instead of the pectin of unknown grade. The amounts of this pectin used were such that they were equivalent to 0.5 grams of pectins ranging from 100 to 525 grade. It was found by constructing a jelly strength-pH curve that solutions made from this commercial pectin needed no pH adjustment, since the untreated pectin solutions were found to produce the jellies of greatest strength.

[2]The jelly grade of a pectin is expressed as the number of parts by weight of sugar that one part by weight of pectin will cause to gel when the jelly is prepared according to a standardized procedure. Under such conditions, 1 gram of 100 grade pectin will gel 100 grams of sugar.

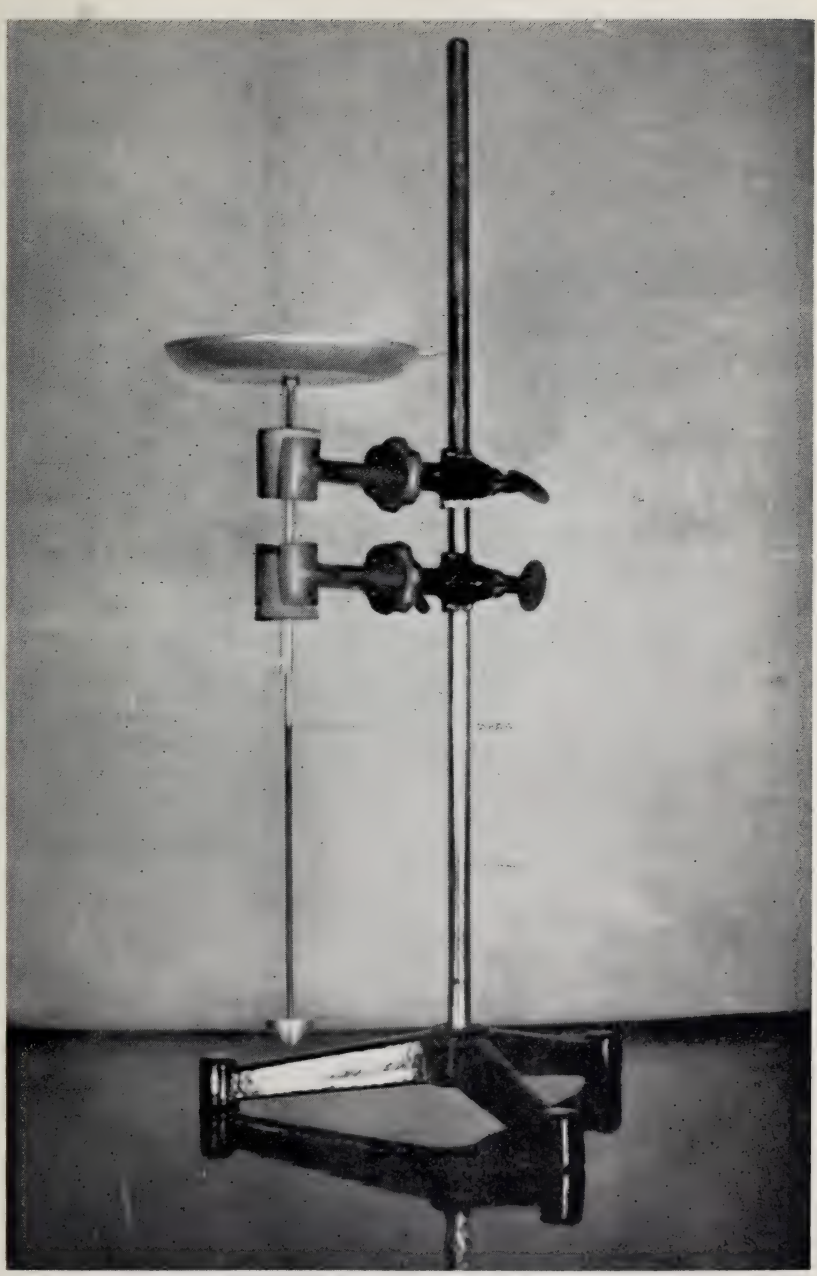

Plate 1—Apparatus used for determining jelly grade.

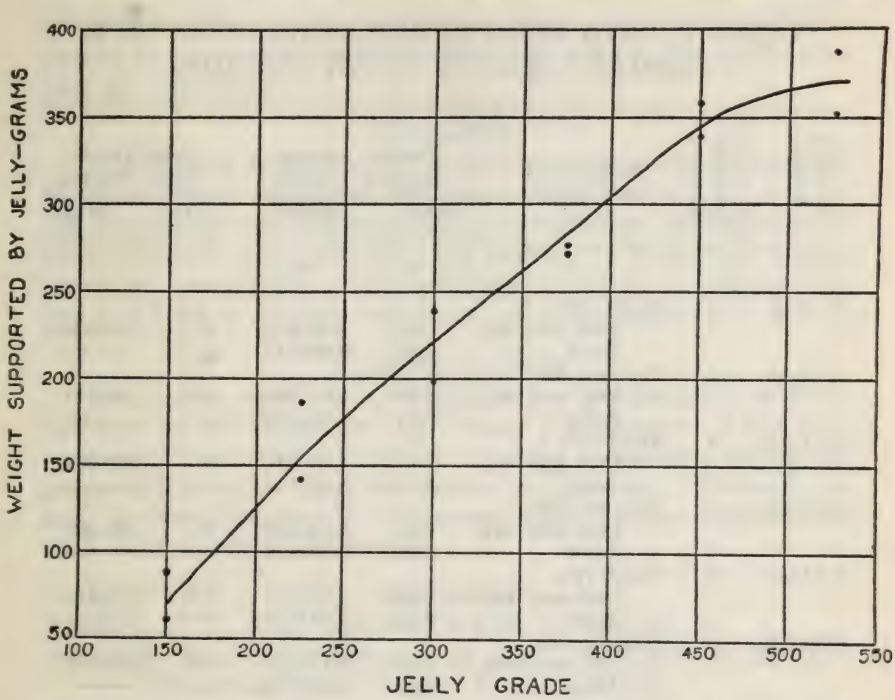

Fig. 1—Curve showing the relationship between the weight supported by a jelly and the jelly grade.

Results

The data obtained as a result of these analyses is presented in table 1. The percentages of pectin were calculated on the fresh fruit basis. It should be remembered, as pointed out previously in this paper, that each composite sample consisted of representative portions of fifty fruit from each individual lot. Thus the number of fruit used in obtaining the figures for the average pectin content and jelly grade varied from 100 to 200 depending upon the number of lots of a particular grade sampled on that date.

TABLE 1. DATA FOR PECTINS EXTRACTED FROM PERSIAN LIMES OF SOUTH FLORIDA.

Sampling Date	No. of Lots* of Fruit Sampled	Description of Sample	Pectin Content (Calcium Pectate)		Jelly Grade (65% Sugar)	
			Avg.	Range	Avg.	Range
			%	%		
7/ 3/45	3	Field run				
		Peel and rag	2.68	2.60-2.81	411+	**343-525+
		Juice	0.08	0.06-0.11	——	——
7/ 3/45	2	Number 3's				
		Peel and rag	2.69	2.33-3.05	420	388-451
		Juice	0.07	0.06-0.08	——	——
7/17/45	4	Field run				
		Peel and rag	2.93	2.84-3.17	338	259-392
		Juice	0.06	0.02-0.15	——	——
7/17/45	2	Number 3's				
		Peel and rag	3.18	3.03-3.32	373	341-404
		Juice	0.11	0.05-0.16	——	——
7/31/45	3	Field run				
		Peel and rag	2.83	2.23-3.23	375	370-378
		Juice	0.03	0.03-0.03	——	——
7/31/45	2	Number 3's				
		Peel and rag	3.19	3.17-3.21	335	264-405
		Juice	0.08	0.07-0.09	——	——
8/14/45	4	Field run				
		Peel and rag	3.11	2.82-3.38	427+	336-525+
		Juice	0.05	0.03-0.07	——	——
8/14/45	2	Number 3's				
		Peel and rag	3.10	3.07-3.12	358	336-380
		Juice	0.15	0.15-0.15	——	——

*Each composite sample consisted of representative portions of each of the fifty fruit from a respective lot.

**(+) Indicates that one of the jellies had a higher grade than 525 which was the upper limit of the calibration curve.

The data do not show any consistent differences in the quantity or quality of pectin contained in the different grades of fruit. It is apparent that a good yield of pectin of exceptionally high grade can be extracted from the peel and rag of either "field run" or "Number 3" limes. The pectins, precipitated from the extracts with alcohol and used in the jelly grade determinations, were almost a true white and compared favorably in appearance with a sample of commercial 150-grade citrus pectin. No attempt was made to determine the grade of the small amount of pectin contained in the juice extracts. Due to the rather limited nature

of this investigation,[3] no definite conclusion can be reached with regard to any seasonal variation that may exist in the pectin content of these fruit.

Conclusion

It is obvious from the results of this preliminary investigation that the Persian lime is an excellent source of pectin. In view of the diversified uses of pectin and its derivatives in the fields of food, industry, and medicine, it is planned to undertake a more extensive investigation of the possible utilization of lime residue and cull fruit as an additional source of these products.

Acknowledgments

The author wishes to acknowledge her indebtedness to those members of the Chemistry and Botany Departments of the University of Miami who offered many helpful suggestions during the course of this study. Acknowledgment is also made to Florida Lime and Avocado Growers at Princeton, Florida who supplied the fruit used in this investigation.

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[3]The hurricane which recently swept through this area caused so much damage to the lime groves that it was impossible to continue the investigation this year.

FACTORS AFFECTING THE GROWTH AND DISTRIBUTION OF MYXOPHYCEAE IN FLORIDA

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This paper reports the study of some physical, chemical and biological factors affecting the growth and distribution of Myxophyceae collected in three closely related sinks. These sinks are located in a suburban area of Gainesville, Florida. They form an approximate right-angled triangle. Sink I, located at the southwest corner of the triangle, is 450 feet from Sink II at the northwest corner. Sink II is 750 feet from Sink III at the southeast corner, and Sink III is 550 feet from Sink I (Fig. 1.).

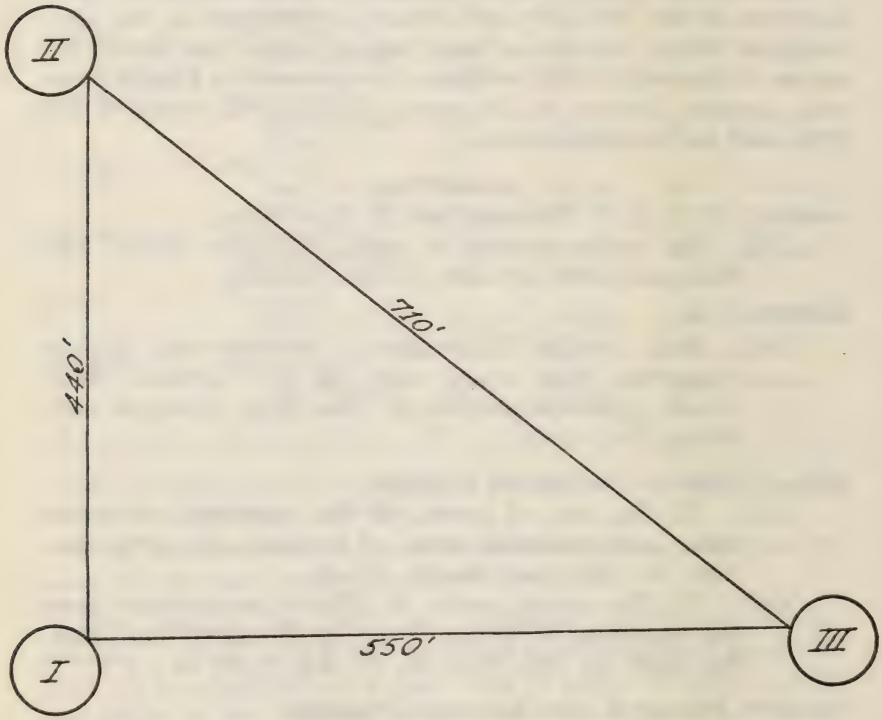

Fig. 1—Showing the relation of Sinks I, II, III and the dimensions of the right angle triangle formed by their locations.

During a ten year interval, the average annual rainfall in this area was 48.90 inches.

Table I. Showing Monthly Rainfall in Inches During the Years 1941-1943

	1941	1942	1943
January	3.51	4.04	1.45
February	3.02	4.54	0.12
March	2.27	7.25	2.77
April	3.71	0.52	2.86
May	1.77	0.54	4.94
June	6.57	9.31	5.70
July	5.76	2.79	6.50
August	6.12	5.08	8.07
September	3.15	5.88	5.41
October	15.78	2.21	0.26
November	2.90	0.39	0.40
December	6.24	4.76	2.43
TOTAL	60.80	47.31	40.91

These records exhibit pronounced monthly and annual variation in precipitation. During the first eight months of 1941 the precipitation was normal. The water supply in the sinks was favorable for plant growth. However, very few Myxophyceae were collected. In September a single genus and species were found in Sink I, and none in Sinks II and III. In October there was an exceptional rainfall of 15.78 inches. This affected several physical and chemical factors, but no noticeable increase in population of algae, and no increase of genera and species were observed.

In 1942 the monthly rainfall was very irregular. During three months of the year it was less than an inch per month. Such irregular precipitation causes changes in concentration of solutes, osmotic pressure, and pH. It was expected that some correlation between these changing physical and chemical factors and the number of genera and species of Myxophyceae collected might be found. No correlation could be determined. During the greater portion of this 15 months study the water in each sink covered 1/2 acre of area. The water level varied 5 feet in 1941 and 4 feet in 1942.

The following Myxophyceae were collected during the period from September 1, 1941 to December 1, 1942. The dates of collection of each species reported are indicated. The greatest number of species was collected in October of 1942.

Sink I

Lyngbya Diguetii Gom. 9-17-41
11-26-41
Lyngbya putealis Gom. 11-13-41
Chlorococcum humicola Nag. 2-14-42
Anacystis marginata Menegh. 6-13-42
Anacystis rupestris Drouet. 1- 5-42

Sink I—Continued

Aphanocapsa Grevillei (Bark.) Rabenh.	6-13-42
	8- 5-42
Aphanocapsa Richteriana Hiron.	6-13-42
Oscillatoria tenue var. *natans* Gom.	1- 5-42
Lyngbya Patrickiana Drouet	8- 5-42
	10- 6-42
Lyngbya Taylorii Drouet and Strickl.	10- 6-42
Lyngbya aestuarii Gom.	10- 6-42
	10-21-42
Lyngbya versicolor Gom.	10- 6-42
	11-10-42
Phormidium autumnale Gom.	11-10-42
Nostoc Hederulae B. and F.	4- 8-42
	6-13-42
Nostoc humifusum B. and F.	10-20-42
Alosira implexa B. and F.	8- 5-42
	10- 6-42
Fremyella diplosiphon (B. and F.) Drouet	2-14-42
Scytonema coatile B. and F.	8- 5-42
	10- 6-42

11 Genera — 18 Species

Sink II

Nostoc Muscorum B. and F.	10-10-41
	10-21-41
	10-25-41
	10-26-41
	8-24-42
Calothrix parietina B. and F.	11-25-41
Plectonema Nostocorum Gom.	11-25-41
	10- 6-42
Oscillatoria anguina Gom.	10- 6-42
Oscillatoria chlorina Gom.	10- 6-42
Oscillatoria princeps Gom.	10- 6-42
Oscillatoria tenue var. *natans* Gom.	10- 6-42
Microcoleus lacustris Gom.	8-24-42
Anabaena oscillarioides B. and F.	4- 8-42
Scytonema ocellatum B. and F.	8-24-42
Fischerella ambigua (B. and F.) Gom.	10- 6-42

8 Genera — 11 Species

Sink III

Polycystis aeruginosa Kutz.	10-23-41
Anabaena circinalis B. and F.	10- 9-41
	3-26-42
	3-27-42
	3-29-42
Anabaena flos-aquae B. and F.	3-26-42
	3-27-42
	3-29-42
Oscillatoria Agardhii Gom.	6-13-42
	6-24-42
	6-30-42

3 Genera — 4 Species

Distribution

These lists show selectivity and individuality in habitat of the Myxophyceae reported in this study. Only four of twenty-four genera were found duplicated in two sinks—(*Oscillatoria, Nostoc* and *Scytonema* in Sinks I and II, and *Anabaena* in II and III). Also only one species was duplicated in two sinks—(*Oscillatoria tenue* var. *natans* in Sinks I and II).

Figure 1 shows the intimate relation of the three sinks. When the animal agents associated with these sinks (turtles, herons, domestic ducks, dogs and human beings) are considered, it would seem that there should have been more inter-sink distribution and duplication than was found. Since Myxophyceae have no means of moving from sink to sink by their own power, but must depend wholly on biotic agents, there is, of course, a large element of chance in their distribution, even in such closely related sinks as I, II, and III. The problem called for an examination and appraisal of some of the physical, chemical and biological factors affecting these algae in order to find a solution.

The factors considered were light, heat, osmosis, and radioactivity; mineral nutrients, oxygen, carbon dioxide and pH; overcrowding of living forms, and possible excretion of growth substances which might retard or accelerate growth.

Sink I is located in an open area which is free from surrounding shrubs and trees. In the summer Lotus leaves and Panicum grass form a shade border ten feet wide around the outer zone of the sink. This growth cuts the light and lowers the temperature slightly. The light and heat factors are very high in Sink I in the summer. They are exceedingly favorable for photosynthesis and growth and reproduction of Myxophyceae. In contrast Sinks II and III are closely surrounded by shrubs and trees. Also in Sink II a dense carpet of *Spirodela polyrhiza* developed over the major portion of the water area. These timbered borders and carpet seriously affected both light and heat. The result was registered, to some extent, in the reduction of genera and species of Myxophyceae in II and III.

Osmosis was somewhat higher in Sink III than II and I. The difference in this factor, however, did not affect the growth and distribution of the algae to any measurable degree.

Radioactivity was suggested as a possible factor in this problem. The results secured from precision tests of water samples from each sink answered this suggestion in the negative.

Chemical analyses of the water in each sink gave the following results:

	Sink I	Sink II	Sink III
Bicarbonate Alkalinity (Calc. as $CaCo_3$	61.0	32.5	72.8
Insoluble Residue Si_2 plus $BaSo_4$, etc.	3.6	6.8	4.0
R_2O_3 meaning $Fe_2O_3+A1_2O_3$	8.4	4.4	3.2
CaO determined gravimetrically	41.6	27.8	36.0
Total p.p.m. as reported (analysis)	114.6	71.5	116.0

Free oxygen was present in abundance for respiration of algae in all sinks.

Ample carbon dioxide was secured from the Bicarbonates for the photosynthesis of the algae.

The mineral nutrients, calcium, iron and phosphates were in adequate quantities for the normal metabolism of all algae and higher plants present in the sinks.

The factor of pH was studied carefully in the case of each sink. Many collections of water were made during the time this study was made. The minimum and maximum readings were:

		Sink I	Sink II	Sink III
pH	Min.	6.92	6.26	6.92
	Max.	8.75	7.80	9.15

This factor varies when the CO_2 varies from high in the morning, after the low light of night, to a lower level in the sunlight and resulting photosynthesis. It varies with changing concentration of the solutes, which are acid, base or salt, in sink water. The pH factor is such a dominant agent in the metabolism of the living organism that it must have great importance in growth and multiplication of Myxophyceae. Pasteur, who first recognized its significance in all living forms, affirmed that "each plant has its optimum and minimum concentration of pH for growth. Not only different species, but different races of the same plant show different requirements with reference to pH."

Bonner (1934) pointed out that the magnitude of growth substance effects is directly related to the hydrogen-ion concentration of the medium in which growth substance is applied. He concluded from his study with *Avena* coleoptile that the growth substance is converted from the form of an inactive salt to an active, non-dissociated form in the presence of acid buffers.

Marmer (1937) also found that the effect of growth substance on the growth of wheat seedlings is related to the pH of the applied solution. She reported that indole-3-acetic acid is 15,000 times as effective at pH 4.6 as at pH 7.5, and that indole-butyric acid is 10 times as effective, and indole-propionic acid is 20 times as effective at these respective levels of pH.

Albaum, Kaiser, and Nestler (1937) found that the penetration of indole-3-acetic acid into cells of *Nitella* takes place more rapidly at pH 3.65 than at pH 7.94. On the basis of their results they concluded that the hydrogen ion concentration affects the degree of dissociation of molecules of growth substance and that the heterauxin enters cells of *Nitella* in molecular form.

All of these research workers secured results in complete agreement with Pasteur's appraisal of pH action. He stated that "one might as well expect to get the same chemical reactions at different levels of pH as to get the same chemical reactions at different degrees of temperature."

In view of the importance and power of hydrogen-ions, and the greatly increased biological-chemical action when optimum pH levels are employed, it is suggested that the hydrogen-ion may have a large effect in growth of Myxophyceae growing in sinks I, II, III. Other factors are involved, indubitably, in causation of the variables reported in this study—such as only one species out of 33 appearing in 2 sinks, and only four genera out of 22 being found in a second sink.

The biological factors of crowding and secretion of accelerating and retarding substances were observed in the genus *Anabaena*. On the 26th of March 1942 there was an excessive growth of *Anabaena circinalis* and *A. flosaquae* in Sink III. The precipitation during the preceeding 7 months had been over 40 inches. The temperature was 24° C, and the pH was 8.87. These were very favorable for the rapid development of *Anabaena*. A green, cream-like mass covered the water surface, and there were over 100 million plants p.c.c. This condition reached its maximum state within 96 hours. Then there was decline in numbers and a gradual disappearance of *Anabaena*. The excretion of oil caused a disagreeable odor about the entire sink during the period of maximum growth. This seemed to be associated with decline of growth and disappearance of the alga. This was the only example of the accelerating and retarding effects of crowding and excretion of toxic products by any of the Myxophyceae reported in this study.

The variable number of genera and species of Myxophyceae growing in the closely associated sinks I, II, III, presents a paral-

lel which has been observed by algologists in other parts of Florida and the world. It is interesting to learn from L. H. Tiffany (1944:99) that he had similar experiences with collections of Oedogoniales. He states that "A pond scarcely more than an acre in area located in a cypress "strand" just south of Arcadia, Florida, yielded thirty-one species and two varieties of *Oedogonium* and *Bulbochaete*. This large number was not equaled anywhere else in the state, although most of the ponds in cypress swamps were highly productive. It is very difficult to understand the diversity of yield in what appear to be very similar bodies of water. Nearly every algologist has had the experience of discovering a pond, or other habitat, in a given area unusually rich in species when compared with apparently similar habitats in the same area. Until biological investigations can be carried out in different localities over a period of years, the relations of environmental factors to algal productivity as well as the accident of introduction through carrier agents such as birds can be surmised but not accurately gauged."

After discussing *dormancy,* permanency of habitat, proper environmental conditions, and the accident of dispersal or rise of species by some heritable variation, he (Tiffany, 1944:100) concluded that "these intriguing problems cannot all be solved in a day or a year or even a lifetime, but the patient accumulation of ecological, physiological, morphological, and genetical data on the *Oedogoniales* will some day make it possible for us to see through much of the haze that now surrounds the explanation for the distribution of the members of this algal group."

Summary

In this study of factors affecting growth and distribution of Myxophyceae collected in Sinks I, II, and III, a total of 22 genera and 33 species were identified. Four physical, four chemical and two biological factors were considered relative to growth and distribution. Only one of the ten factors mentioned seemed to have the rank of a limiting factor in growth and multiplication of units, and thus indirectly influenced distribution by reason of increasing population. This factor was the hydrogen-ion. This conclusion was supported by evidence that the magnitude of growth in higher plants was definitely due to the effect of the hydrogen-ion.

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THE CRICKET-FROG OF PENINSULAR FLORIDA

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Field studies in the southeastern states and laboratory examination of large series of freshly preserved specimens have convinced us that the cricket-frogs of peninsular Florida comprise a recognizable, homogeneous population. For this form the following name is available:

Acris gryllus dorsalis (Harlan)
(Plate 1, upper fig.)
Florida Cricket-frog

Rana dorsalis Harlan, Journ. Acad. Nat. Sci. Philadelphia, ser. 1, 5: 340, January, 1827.

Diagnosis

A cricket-frog with *two* distinct dark postfemoral stripes present; no anal warts; toes very slender and delicate; size small (adult females seldom exceeding 20 mm in snout-to-vent length). The thigh patterns and anal wartiness of *dorsalis, gryllus,* and *crepitans* are illustrated upon the accompanying plate.

Type Locality

As more than one form of *Acris* occurs in Florida, we have checked the itineraries of collectors who visited Florida prior to 1827, in an attempt to find the most likely source of the specimens which Harlan used in describing *dorsalis.* Fortunately, this was before many herpetological explorations of the State had been made, and it appears probable that Harlan's specimens were obtained by one of two parties.

In 1818, Thomas Say, in company with William Maclure (then President of the Philadelphia Academy), George Ord and T. R. Peale, ascended the St. John's River to "about 100 miles from its mouth" (as far as Picolata in what is now St. John's County), seeking "subjects of Nat. Hist. of which the acquisition was the sole object of our undertaking" (see Fox, 1901: 235). In 1822, according to Vignoles (1823: 67), Captain John Le Conte ascended the St. John's to about the same point that John Bartram had reached in 1766. Dr. Francis Harper informs us that this was about the latitude of Titusville. We do not know where or how much Le Conte collected on this trip, but it may be significant that Carr (1938: 105) considers that the specimens described by Le Conte from the St. John's as *Testudo floridana (=Pseudemys f. floridana)* were probably "collected in the lower (northern) reaches of the river."

PLATE 1.

Miss Mary Cleeves, del.

Typical postfemoral patterns of *Acris*. x8.

Upper. *Acris g. dorsalis*. CM no. 17123, Fla., Alachua Co., 1/2 mile east of Gainesville.

Center. *Acris g. gryllus*. CM no. 16845a, Ga., Liberty Co., Riceboro.

Lower. *Acris crepitans*. CM no. 4800a, Mich., Washtenaw Co., Ann Arbor.

So far as we know, these were the only two major herpetological collecting expeditions made to Florida prior to Harlan's description of *dorsalis* in 1827. Dr. Harper informs us that he believes, on the basis of his investigations of early biological explorations in Florida, that the material used by Harlan probably was collected on one of these two trips.

We have specimens of *Acris* collected on the St. John's River, in St. John's County, by the junior author, which are typical of *dorsalis* as herein defined. We, therefore, restrict the type locality of *Rana dorsalis* Harlan to the lower (northern) one hundred miles of the St. John's River.

Description

Harlan's description, although brief, is very much to the point and there appears to be no doubt that he had specimens of the peninsular form at hand. Dunn (1938: 154) states that he has been unable to locate the types of *dorsalis;* hence decision as to the applicability of Harlan's name must be made on the basis of characters used in his description. This is quoted in full:

> *Char.—Above* fuscous, smooth, with a broad, white, longitudinal vertebral band, bifurcating anteriorly, and extending over each eye: *snout* above, pale or whitish: *beneath* white: *throat* and inner part of the thighs freckled: *buttocks* white, with two brownish transverse lines: a white line on the side of the neck, extending from the eye to the scapula.
>
> Length of the body 8/10 of an inch; of the legs 1-1/2 inches. This measurement being taken from the largest of seven specimens. Inhabits Florida. Specimens in the Cabinet of the A. N. S.

Of the two heretofore recognized forms of *Acris, gryllus* and *crepitans,* only the former need be considered in connection with this description, for *crepitans* would not be described by any careful observer as having "buttocks white with two brownish transverse lines"; nor does it inhabit the southeastern lowlands. Occasional southern specimens of *gryllus* do have such a thigh pattern, but the fact that Harlan redescribes *gryllus* very accurately on the same page indicates that he was well acquainted with this form. Furthermore, many of our specimens of *dorsalis* display exactly the dorsal pattern mentioned by Harlan, namely, "a broad, white longitudinal vertebral band, bifurcating anteriorly, and extending over each eye"; the latter portion of this statement is the most important, for specimens of *gryllus* rarely exhibit an anterior bifurcation of the dorsal stripe; in *gryllus* this stripe usually begins at the apex of the postocular triangle. Furthermore, *dorsalis* does not exhibit the elongate dorsal warts so frequently seen in *gryllus,* although many specimens have the dorsum well covered

with small rounded warts; the size mentioned (.8 inch = 20 mm) corresponds accurately with the measurements of a large number of *dorsalis* and is too small for the largest specimen in almost any series of adult *gryllus* selected at random.

Variation

The typical pattern of the posterier thigh of *dorsalis* consists of two longitudinal white stripes and two longitudinal brown stripes. When the thigh is viewed from the rear, the stripes from the dorsal to the ventral surface are as follows: 1) A clear white stripe bordering the colored dorsal surface of the thigh and very well defined along this border because both the dorsal ground color and the superimposed spots are generally darker in *dorsalis* than in *gryllus;* both edges of this stripe are usually straighter than in *gryllus*, the stripe is usually broader, and it approaches the vent more closely at its proximal end than it does in *gryllus*. 2) A dark brown stripe beneath the superior white stripe, extending from the vent to the knee, usually narrower than the same stripe in *gryllus*, more straight-edged above and below, and frequently narrower than the white stripes which border it. 3) A second or inferior white stripe which is usually equally as distinct as the upper white stripe. The two white stripes vary considerably in width; they may be similar in width, the upper may be the broader, or the lower may be the broader, but, in any event, they appear to have been widened at the expense of the brown stripe which they enclose. Harlan's description of the buttocks as white with two transverse [= longitudinal] brownish lines conveys the correct impression. 4) A light brown stripe beginning immediately below the vent and extending diagonally so that its distal end is always on the ventral surface of the thigh and sometimes (depending upon preservation) the entire stripe is ventral in position. This stripe is rarely as dark as the superior brown stripe, and it is generally uniform in color from edge to edge, not browner at the margins as in those few *gryllus* which display a similar stripe. The inferior brown stripe is almost always visible from behind in *dorsalis* and is always a definite stripe, whereas the most frequent pattern in *gryllus* is a general suffusion of brown below the inferior white stripe, resulting in a triangular dark area which lies immediately below the vent and which reaches a point beneath the knee.

The last mentioned characteristic offers the best means of separating *gryllus* and *dorsalis*, but it is not invariably satisfactory. For example, two of a series of eleven topotypes of *gryllus* have clearly defined inferior brown stripes which are diagonal, but these are the darkest specimens in the series and the white stripes

are both narrower and less sharply demarcated than in *dorsalis*. Such specimens of *gryllus* with an excess of dark pigment concentrated into a stripe have much more heavily marked thighs when viewed from beneath than do specimens of *dorsalis*. It must be noted that the distinctness of the thigh pattern in Atlantic Coast *gryllus* increases as latitude decreases. Virginia specimens show little resemblance to *dorsalis*, Riceboro topotypes occasionally approximate *dorsalis* in thigh pattern although their adult size is larger, and southern Georgia specimens are the most difficult of all to distinguish from *dorsalis*.

Preserved specimens of *dorsalis* may or may not have a brown triangle on the head; this triangle may be completely bordered by white, it may be bordered on the sides only, or it may be without light edging. The mid-dorsal stripe may be narrow and white, broad and light brown (sometimes green in life), or absent. The pattern of the back may consist of an anterior pair of blotches which resemble reversed parentheses, followed by a posterior pair of diagonal club-shaped spots; or the two spots on each side may be confluent with distinct lobes directed laterally; or a single pair of curved spots may be present, in which case the elongate spot on each side is rarely as much broadened throughout its length as in *gryllus*. A white line from the eye to the shoulder is almost invariably present; the dorsal surfaces of the thighs are marked with narrow bars or blotches; the belly is immaculate or lightly freckled anteriorly; the throat ranges from a heavily spotted condition in some males to an immaculate condition in a few specimens.

The amount of webbing is highly variable even in a series of specimens collected at the same time and place, and apparently cannot be correlated with sex. The web is always broadly attached to the base and sometimes to the middle of the penultimate phalanx of the fourth toe and extends along this toe as a narrow margin to the disc; it is always broadly attached as far as the base of the ultimate phalanx of the fifth toe and sometimes to the disc; similarly, it is always broadly attached at the base of the ultimate phalanx of the third toe, and sometimes beyond the middle of this phalanx. Describing webbing on the basis of the number of joints free is not wholly satisfactory in this genus; *crepitans* has the most completely webbed feet and it also has by far the largest feet, so that when the toes are spread there is a very impressive amount of web. The feet of *gryllus* are smaller and appear less fully webbed than those of *crepitans*. The trend toward narrower feet continues in *dorsalis*, which has toes that are slightly more slender

than those of *gryllus* and do not spread apart so widely, so that the foot appears to have less web. In spite of this, no constant difference in point of attachment of the web on various toes has been noticed in comparing *dorsalis* and *gryllus*.

A. g. dorsalis appears to be the smallest form in the genus. Thus, 146 specimens from peninsular Florida range from 13 to 21 mm and average 17.3 mm in snout-to-vent length. In *dorsalis* the heel of the extended hind leg generally reaches beyond the snout.

Habits

The junior author, who is well acquainted with *dorsalis* in the field, first became convinced that it differs from the cricket-frog of West Florida when he noted differences in the behavior of the two populations. In endeavoring to escape capture, *dorsalis* proceeds by a number of short leaps with frequent changes of direction, whereas *gryllus* in West Florida often leaps as much as five or six feet and maintains a relatively straight course. In addition, *dorsalis* exhibits a greater tendency to hide under concealing bits of vegetation either in the water following a dive, or upon land after a few short hops; under similar circumstances *gryllus* may come to rest upon the open beach or upon a grass stem in full view until the collector approaches sufficiently close to stimulate the frog into making another long leap.

On April 17, 1939, at a small pond about three miles east of Gainesville, the junior author observed *dorsalis* tadpoles feeding upon free-swimming colonial rotifers *(Conochilus?)*. The tadpoles, at subtransformation stage, were numerous in the pond. Individuals were observed to swim slowly up to a colony of rotifers and then suck the entire colony into the mouth. In some instances the colonies were too large to be swallowed and after a few futile attempts the tadpole would desist and swim off in search of a colony of smaller size.

Range

We have seen specimens of *A. g. dorsalis* from the following Florida counties: Alachua, Broward, Clay, Dade, Duval, Hillsborough, Lake, Levy, Marion, Polk, Putnam, Sarasota, Seminole, St. John's, and Volusia. A series of nine specimens from near St. Marys, Camden County, Georgia, and a single specimen from five miles north of Yulee, Nassau County, Florida, are, in most respects, intermediate between *gryllus* and *dorsalis*. Every variation in femoral pattern from that of *gryllus* to that of *dorsalis* is exhibited by these specimens, but their patterns average somewhat closer to

that of *dorsalis*. On the other hand, in body size and in the lack of distinct dorsal stripes they approximate *gryllus* more closely. One series of 27 specimens from Leon County, Florida, includes a number of adults which exhibit a good *dorsalis* thigh pattern, but these are large in size and extremely dark dorsally. The range of *A. g. dorsalis,* then, may be stated as from Duval and Jefferson counties, Florida, south throughout the peninsula. Typical *gryllus,* as we understand it, ranges from about Dismal Swamp, Virginia, southward along the Atlantic Coastal Plain to about the Florida-Georgia boundary, where it intergrades with *dorsalis*. Specimens which differ in certain respects from typical *gryllus,* but which are best retained under this name at present, range along the Gulf Coastal Plain from Leon County, Florida, to New Orleans.

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Fig. 1—Ocala Chamber of Commerce Building constructed from limerock concrete.

Fig. 2—The Gainesville Livestock Market Office Building constructed with limerock concrete masonry units.

Fig. 3—Poured limerock concrete construction (residence built by Mr. B. F. Williamson in Gainesville, 1929).

PROPERTIES OF LIMEROCK CONCRETE

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Two kinds of limestone occur in Florida; the hard variety and the soft variety known locally as limerock. The amount of hard limestone available is small compared to the total amount of soft rock, hence the experimental work described here was concerned solely with use of the soft variety. This limerock is found in abundant quantities in the north-central and central parts of the state, extending in the west to the Gulf Coast. Limerock is a soft and friable high calcium limestone of white to cream color made up of marine fossil remains laid down during the Eocene Age. It is obtained by open pit mining and is generally crushed before use. Since the limerock contains no clay or organic material, washing or other processing of the natural material is not necessary.

The most extensive uses of limerock have been as a sub-base for highways and as a concrete aggregate. It offers unusual properties for road building such as high stabilization values, low cost, local availability, and ability to be reworked. For use as a concrete aggregate it is cheap, available, and produces a reasonably strong product in an economical mix. Much limerock is being used as aggregate in the manufacture of concrete masonry units. Numerous buildings and pavements have been constructed using monolithic limerock concrete and limerock concrete masonry units (Figs. 1 and 2). These constructions show excellent resistance to the weather and, in fact, weathering brings out the pleasing white to cream color of the limerock. Figure 3 shows an all concrete residence of poured limerock concrete constructed in Gainesville in 1929 by Mr. B. F. Williamson. Even the roof structure is limerock concrete. This residence, according to the owner, is satisfactory in every way.

The newest field of application of limerock concrete is in the construction of concrete highways. In the fall of 1944, the State Road Department, in cooperation with the Limerock Association of Florida and with the advice of the University of Florida Engineering and Industrial Experiment Station, constructed 4500 lineal feet of experimental limerock concrete road just north of Gainesville on US 441. In this construction three different mixes

were used in three different cross sections, thus giving nine different concrete sections which will show the suitability of limerock concrete for highways in Florida. At the present time every section is completely satisfactory.

Strength of Limerock Concrete

The compressive strength of various limerock concrete mixes has been studied for several years at the University of Florida in an effort to encourage the use of limerock as a concrete aggregate. The results of this work have been published in Bulletin 7, "Limerock Concrete, Part I."[1] This bulletin covers the method of mixing and placing limerock concrete, effect of mixing water on compressive strength, and the most favorable conditions for limerock concrete. It shows the need for careful water control in mixing limerock concrete, and includes compressive strength data for the various mixes from 1:5 to 1:9 by volume. The 1:7 mix by volume has generally been found to be the most economical mix. This mix (1:7) with 0-1" slump will give a 28-day compressive strength of about 1500-2000 psi. Figure 4 shows the mixing water/cement ratio vs. compressive strength curve for various mixes, based on the data taken from Bulletin 7.

The most recent test work on limerock concrete was done by the State Road Department and the Portland Cement Association Research Laboratory, Chicago, in studies for the experimental limerock sections on US 441 just north of Gainesville, Florida. Both the S. R. D. test data and the P. C. A. results are summarized in the Florida State Road Department's "Preliminary Report of Experimental Limerock Pavement Test Sections." The data in Table I are taken from this report. The screen analysis of the limerock aggregate is very important. For best results the aggregate should all pass the 1" screen. The following screen analysis is approximately the same as that of the aggregate used in the experimental pavement test sections on US 441.

The laboratory tests made by the State Road Department are in satisfactory agreement with the values in Table I found by the P. C. A. Research Laboratory; both results substantiate the data in Bulletin 7 and are further proof that limerock is a satisfactory aggregate for 1500-2000 psi strength concrete.

[1]Univ. Florida Eng. & Ind. Exp. Sta., Bull. 7.

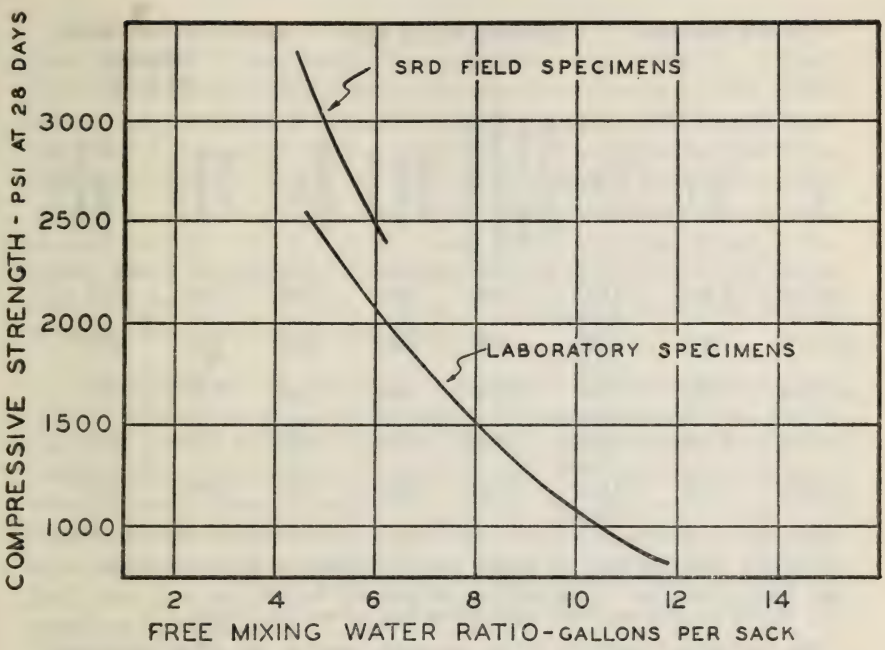

Fig. 4—Compressive strength at 28 days vs. free mixing water-cement ratio for limerock concrete.

TABLE I

STRENGTH AND MODULUS OF ELASTICITY OF LIMEROCK CONCRETE SPECIMENS FROM THE FLORIDA STATE ROAD DEPARTMENT

by

The Portland Cement Association

Unvibrated specimens were cast on June 28, 1944, by the State Road Department test laboratory in Gainesville. They were cured one day under wet burlap, one day in a moist room and then packed in wet sawdust for shipment to Chicago. They were received at the Chicago Research Laboratory on July 20, placed in a moist room July 21 until tested at 28-day age on July 26, 1944. Slump of concrete was 2 in. Beams were loaded on their sides as cast, at 1/3 point of 27 in. span.

Mix Proportion			Strength at 28 days		Modulus of Elasticity (Beams) psi x 10^{-6}		
Wt.	D.R. vol.	w/c by vol.	Compression (6"x12" cylinders) Average of 2 cylinders	Flexure 6x6x30" Beams	Dynamic (a)	Initial tangent (b)	Secant at 1000 psi (c)
94:582	1:6.2	1.013 7.6 gal.	1360	280	1.98	2.00	1.34
94:456	1:4.9	0.893 6.7 gal.	1675	350	2.22	2.26	1.44
94:374	1:4.0	0.720 5.4 gal.	2115	360	2.40	2.43	1.54
94:308	1:3.5	0.653 4.9 gal.	2405	420	2.60	2.66	1.66
94:257	1:2.7	0.613 4.6 gal.	2745	480	2.86	2.86	1.89

(a) Tests made on July 21 before placing specimens in moist room.
(b) Tests made on July 26 after 5 days in moist room.
(c) Values calculated from load-deflection curves for beams.

The mechanical analysis of the aggregate used in the above laboratory samples was as follows:

Total passing	1-1/2"	sieve	100%
" "	1"	"	96
" "	3/4"	"	93
" "	1/2"	"	89
" "	3/8"	"	84
" "	4	mesh	73
" "	8	"	64
" "	16	"	52
" "	30	"	43
" "	50	"	31
" "	100	"	17
Fineness modulus			3.43
Dry rodded weight per cu. ft.			94 lbs.
Absorption			14.0%

THERMAL PROPERTIES

Thermal Conductivity of Limerock Concrete Walls

Since limerock concrete is finding extensive use in the building trades in the form of both monolithic and block structures, it was thought that the heat conductivity properties of the concrete should be determined. The thermal conductivity values of limerock concrete at different moisture contents have been measured and will be reported in a paper to be published elsewhere.

The coefficient of thermal conductivity, k, of limerock concrete is a function of temperature, composition, and moisture content. The effect of composition is to increase the value of k with richer mixes, e.g., the 1:5 mix by volume has a k that is 10% larger than the k for 1:7 mix by volume. The effect of moisture is also to increase the value of k, e.g., an increase of moisture from zero to 5% increases the k of 1:5 mix by 23%. Therefore, limerock concrete should be kept dry if the maximum heat insulation effect is desired. The k for bone-dry limerock concrete is 0.51 for the 1:7 mix and 0.56 for the 1:5 mix. The k for ordinary sand and gravel concrete is 1.01[2] (1:2.0: 2.75 mix).

The coefficient of thermal conductivity measures directly the rate at which heat will flow through a homogeneous material, but it does not give a complete picture of the heat insulation value of walls or other heterogeneous constructions. For heterogeneous constructions the overall coefficient of heat conduction, U, must be used for such comparisons. For a wall built up of a homogeneous material (such as a poured concrete wall) of conductivity k and x feet thick the coefficient of heat transmission, U, is determined by equation (1) below:

$$\frac{1}{U} = \frac{1}{hi} + \frac{x}{k} + \frac{1}{ho} \qquad (1)$$

where U = the overall coefficient of heat transmission in Btu/(hr) (sq ft) (deg F difference between the air on the two sides), and h = the surface coefficient of heat transfer. Subscript i is used to designate inside coefficient, and o, the outside coefficient.

For a wall with air space construction consisting of two homogeneous materials of thicknesses x_1 and x_2, and conductivities k_1 and k_2, separated to form an air space of conductance a, the coefficient of transmission is

$$\frac{1}{U} = \frac{1}{hi} + \frac{x_1}{k_1} + \frac{1}{a} + \frac{x_2}{k_2} + \frac{1}{ho} \qquad (2)$$

The over-all coefficient of heat transmission, U, is the amount of heat expressed in Btu transmitted in one hour per square foot of the wall for a difference in temperature of 1 deg F between the air on the outside and that on the inside of the wall. There-

[2]Rowley, F. B. and Algren, A. B. "Thermal Conductivity of Building Materials," Univ. Minn. Eng. Exp. Sta. Bull. 12. (1937).

fore the value of U directly determines the insulation value of a given wall. Low values of U mean good insulation construction and high values of U mean poor insulation construction.

Surface Coefficients of Heat Transfer: Heat is transmitted to or from the surface of a wall by a combination of radiation, conduction and convection. Because of these variables the surface coefficients may be subject to wide fluctuations for different materials and different conditions.

Values of h_i in still and in moving air at different mean temperatures have been determined for various building materials.[3] The surface conductances, h_o, for different materials at a mean temperature of 20 deg F for different air velocities are given in the A.S.H.V.E. Guide (22nd Edition, 1944, page 90). These values are available for specific problems; however, the general comparison of the heat insulating value of walls is made using an average value for the surface coefficients h_i and h_o. The usual procedure is to take $h_i=1.65$ as an average inside coefficient and $h_o=6.0$ as an average outside coefficient for a 15 mph wind velocity.[4] All of the coefficients of transmission, U, in this report are calculated on this assumption.

Calculation of U for Poured Concrete Walls: The equation 1, above, is used for calculating the coefficient of transmission, U, of poured concrete walls. The following data are used in the calculations of U of various concrete walls.

$h_i=1.65$
$h_o=6.0$
$x=0.656$ (7-7/8" wall—equivalent of the 8"x8"x16" block wall)
$k=1.01$[5] for sand and gravel 1:2.0:2.75 mix
$=0.88$[5] for limestone concrete 1:4.75 mix
$=0.56$ for limerock concrete 1:5.0 mix
$=0.51$ for limerock concrete 1:7.0 mix
$=0.23$[6] for clinker concrete

All the k's were determined by the hot plate guard ring method on dry concrete samples. The values of k=0.56 and 0.51 for limerock

[3]A.S.H.V.E. Research Report No. 869. "Surface Conductances as Affected by Air Velocity. Temperature and Character of Surface," by F. B. Rowley, A. B. Algren and J. L. Blackshaw. *Trans. Amer. Soc. Heat. Vent. Eng.*, 36: 429. (1930).

[4]A.S.H.V.E. Guide, 22nd Edition, page 91. (1944). Amer. Soc. Heat. Vent. Eng., 51 Madison Ave., New York, N. Y.

[5]Rowley and Algren, *op. cit.*

[6]Griffiths, Ezer. "Measurement of the Thermal Conductivity of Materials Used in Building Construction." *Jour. Inst. Heat. Vent. Eng.*, 10: 106-138. (1942-43).

concrete in the above list are based on one thickness of test sample as are the other values of k from the literature.

Then the coefficient of heat transmission for various 7-7/8" poured concrete walls is as follows:

Wall No. 1. For a sand and gravel concrete wall:

$$\frac{1}{U} = \frac{1}{1.65} + \frac{0.656}{1.01} + \frac{1}{6.0} = 1.42$$

$U = 0.704$ Btu /(hr)(sq ft)(deg F)

Wall No. 2. For a hard limestone concrete wall:

$$\frac{1}{U} = \frac{1}{1.65} + \frac{0.656}{0.88} + \frac{1}{6.0} = 1.52$$

$U = 0.658$ Btu /(hr)(sq ft)(deg F)

Wall No. 3. For a Florida limerock concrete (1:5 mix) poured wall:

$$\frac{1}{U} = \frac{1}{1.65} + \frac{0.656}{0.56} + \frac{1}{6.0} = 1.94$$

$U = 0.515$ Btu /(hr)(sq ft)(deg F)

Wall No. 4. For a Florida limerock concrete (1:7 mix) poured wall:

$$\frac{1}{U} = \frac{1}{1.65} + \frac{0.656}{0.51} + \frac{1}{6.0} = 2.06$$

$U = 0.485$ Btu /(hr)(sq ft)(deg F)

Wall No. 5. For a clinker concrete poured wall:

$$\frac{1}{U} = \frac{1}{1.65} + \frac{0.656}{0.23} + \frac{1}{6.0} = 3.62$$

$U = 0.276$ Btu /(hr)(sq ft)(deg F)

For a 14 inch sand and gravel concrete poured wall:

$$\frac{1}{U} = \frac{1}{1.65} + \frac{14}{12(1.01)} + \frac{1}{6.0} = 1.93$$

$U = 0.517$ Btu /(hr)(sq ft)(deg F)

Thus it is seen that a sand and gravel concrete wall has to be almost twice as thick as a 7-78" limerock concrete wall to have the equivalent heat insulation value.

Calculation of U for Concrete Block Walls: A standard concrete masonry unit is sketched in the accompanying diagram (Fig. 5). The dimensions of commercial blocks may vary somewhat from

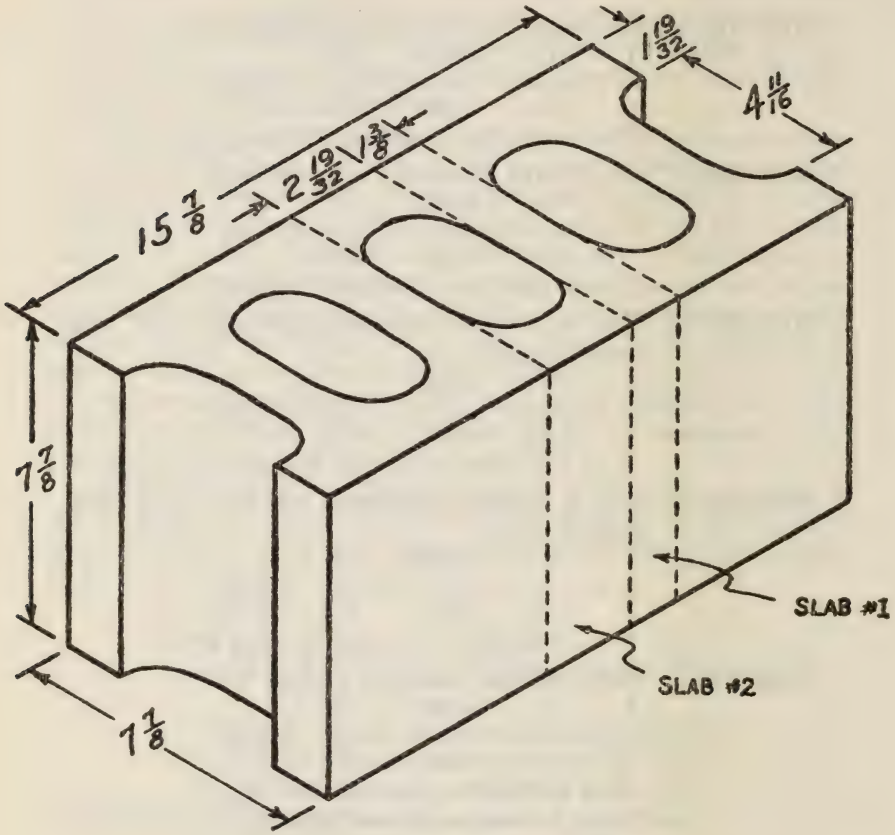

Fig. 5—Standard concrete masonry unit (8x8x16 inches).

plant to plant, but small variations in the dimensions will not affect the calculated results appreciably. For purposes of calculation this standard block can be split up into alternate solid slabs and air containing sections as shown in Fig 5. Slab No. 1 is solid concrete of size 7-7/8"x7-7/8"x1-3/8". Slab No. 2 is a heterogeneous section, size 7-7/8"x7-7/8"x2-19/32", made up of an inside concrete prism, an air space and an outside concrete prism. The dimensions are shown on the sketch in Fig 5. The complete wall can be vis-

ualized as being made up of these two kinds of sections, and therefore, neglecting the mortar joints, the coefficient of transmission can be calculated from a combination of the results of equations 1 and 2. The conductance, a, of the vertical air space in section No. 2 is given as 1.10 in *A.S.H.V.E. Guide* (22nd Edition, page 98, 1944).

Wall No. 6. For a sand and gravel concrete masonry unit wall:

Applying equation 1 to the slab No. 1 gives the following value for coefficient of transmission, u_1, for that section:

$$\frac{1}{u_1} = \frac{1}{1.65} + \frac{0.656}{1.01} + \frac{1}{6.0} = 1.41$$

$$u_1 = 0.71$$

Equation 2 when applied to slab No. 2 gives

$$\frac{1}{u_2} = \frac{1}{1.65} + \frac{1.593}{12(1.01)} + \frac{1}{1.10} + \frac{1.593}{12(1.01)} + \frac{1}{6.0} = 1.95$$

$$u_2 = 0.51$$

Since slab No. 1 comprises 34.6% (1.375/3.97=34.6%) of the face area and Slab No. 2, 65.4% of the face area perpendicular to heat flow, the coefficient of transmission for the complete block or wall is found to be:

$$U = 0.346\ u_1 + 0.654\ u_2$$
$$= 0.346(0.71) + 0.654(0.51)$$
$$= 0.58 \text{ Btu /(hr)(sq ft)(deg F)}$$

This value of U agrees with the data in the *A.S.H.V.E. Guide*, (22nd Edition), very closely. The *Guide* gives U=0.56 for this wall.

Wall No. 7. For a limerock concrete masonry unit wall. Using the thermal conductivity value of 0.51 for 1:7 mix limerock concrete gives the following values for coefficient of transmission of the Wall:

For slab #1

$$\frac{1}{u_1} = \frac{1}{1.65} + \frac{0.656}{0.51} + \frac{1}{6.0} = 2.06$$

$$u_1 = 0.485$$

For slab #2 $\frac{1}{u_2} = \frac{1}{1.65} + \frac{1.593}{12(0.51)} + \frac{1}{1.10} + \frac{1.593}{12(0.51)} + \frac{1}{6.0} = 2.20$

$u_2 = 0.454$

Therefore $U = 0.346\ (0.485) + 0.654\ (0.454)$

$U = 0.46$ Btu /(hr)(sq ft)(deg F)

It is seen that under the same conditions a sand and gravel concrete block wall will conduct 26% more heat through the wall than will a limerock concrete block wall.

Comparison of U for Frame Walls and Concrete Block Walls: The *A.S.H.V.E. Guide,* (22nd Edition, page 100) gives a table of values for coefficients of transmission, U, for common frame walls such as that sketched in Fig. 6. These values are tabulated in Table II together with the coefficients for various concrete walls. All the tabulated values in Table II were determined for the same conditions; i. e., $h_i = 1.65$ and $h_o = 6.0$.

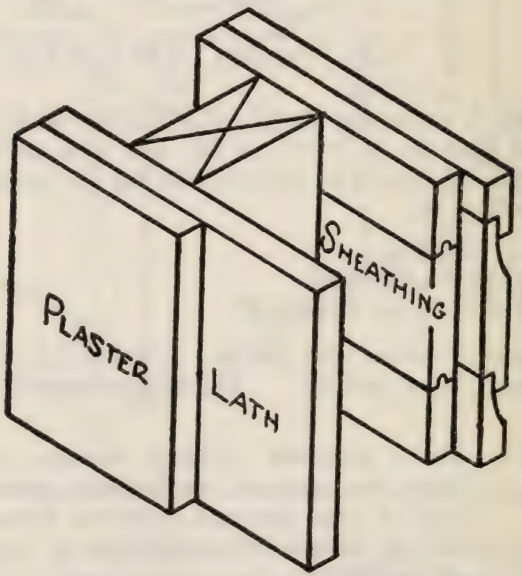

Fig. 6—Common frame construction.

It appears that concrete masonry unit walls cannot approach wood frame structures in insulation value unless they are made of special aggregate concrete blocks or have additional insulation material in the interior. However when interior insulation material is used with limerock concrete blocks or sand and gravel concrete blocks, a wall whose coefficient of transmission is equal to that of a frame wall is obtained.

When sand and gravel concrete block walls have an interior finish consisting of metal lath and 3/4″ plaster on 2″ furring strips, the coefficient of transmission is much reduced. The calculations below (based on the slab method used in the previous section) show how effective this type of interior finish is in reducing the coefficient of transmission. The conductance of each air space (block hole and furred area) is taken as 1.10 and that of 3/4″ plaster on metal lath as 4.40 in accordance with the *A.S.H.V.E. Guide,* (22nd Edition, 1944).

Wall No. 8

For slab #1 $$\frac{1}{u_1} = \frac{1}{6.0} + \frac{0.656}{1.01} + \frac{1}{1.10} + \frac{1}{4.40} + \frac{1}{1.65} = 2.56$$

$$u_1 = 0.39$$

For slab #2 $$\frac{1}{u_2} = \frac{1}{6.0} + \frac{1.593}{12(1.01)} + \frac{1}{1.10} + \frac{1.593}{12(1.01)} + \frac{1}{1.10} + \frac{1}{4.40} + \frac{1}{1.65} = 3.09$$

$$u_2 = 0.32$$

Then the coefficient of transmission of the complete wall is,

U=0.346 (0.39) + 0.654 (0.32)

=0.34 Btu /(hr)(sq ft)(deg F)

Using the same wall construction as Wall No. 8 above and limerock concrete blocks (1:7 mix whose k=0.51) instead of sand and gravel concrete blocks, the coefficient of transmission is as follows:

Wall No. 9

For slab #1 $$\frac{1}{u_1} = \frac{1}{6.0} + \frac{0.656}{0.51} + \frac{1}{1.10} + \frac{1}{4.40} + \frac{1}{1.65} = 3.20$$

$$u_1 = 0.312$$

For slab #2 $$\frac{1}{u_2} = \frac{1}{6.0} + \frac{1.593}{12(0.51)} + \frac{1}{1.10} + \frac{1.593}{12(0.51)} + \frac{1}{1.10} + \frac{1}{4.40} + \frac{1}{1.65} = 3.34$$

$$u_2 = 0.30$$

Then,

U=0.346(0.31) + 0.654(0.30)

=0.30 Btu /(hr)(sq ft)(deg F)

Therefore concrete block walls can be made equal to frame walls (see Table II) in heat insulating effect by finishing the interior of the wall with metal lath and 3/4" plaster on 2" furring strips. Plastering directly onto the concrete blocks would not increase the heat insulating effect of the wall appreciably as it is the air space furnished by the furring strip which gives the increased insulation effect. The air space would also block water transmission through a concrete block wall.

Concrete block walls with an interior finish of gypsum board (3/8") on 2" furring strips would have the same coefficient of transmission as the walls finished with plaster on 2" furring strips.

When the interior finish of a sand and gravel concrete block wall is made up of ½" insulation board (k=0.028) on 2" furring strips the coefficient of transmission, U, is equal to that of the better frame constructions. The following calculations show this in detail:

Wall No. 10.

For slab #1 $$\frac{1}{u_1} = \frac{1}{6.0} + \frac{0.656}{1.01} + \frac{1}{1.10} + \frac{0.5}{12(0.028)} + \frac{1}{1.65} = 3.82$$

$$u_1 = 0.262$$

For slab #2 $$\frac{1}{u_2} = \frac{1}{6.0} + \frac{1.593}{12(1.01)} + \frac{1}{1.10} + \frac{1.593}{12(1.01)} + \frac{1}{1.10} + \frac{0.5}{12(0.028)} + \frac{1}{1.65} = 4.35$$

$$u_2 = 0.23$$

Then the coefficient of transmission of the complete wall is,
U=0.346 (0.262) + 0.654 (0.23)
=0.24 Btu /(hr)(sq ft)(deg F)

Using the same construction as Wall No. 10 above and substituting limerock concrete blocks for the sand and gravel blocks gives a wall with the following coefficient of transmission:

Wall No. 11.

For slab #1 $$\frac{1}{u_1} = \frac{1}{6.0} + \frac{0.656}{0.51} + \frac{1}{1.10} + \frac{0.5}{12(0.028)} + \frac{1}{1.65} = 4.46$$

$$u_1 = 0.224$$

For slab #2 $$\frac{1}{u_2} = \frac{1}{6.0} + \frac{1.593}{12(0.51)} + \frac{1}{1.10} + \frac{1.593}{12(0.51)} + \frac{1}{1.10} + \frac{0.5}{12(0.028)} + \frac{1}{1.65} = 4.60$$

$u_2 = 0.217$

$U = 0.346\ (0.224) + 0.654\ (0.217)$

$= 0.22$ Btu /(hr)(sq ft)(deg F)

These insulated concrete block wall constructions have a coefficient of transmission equal to the better frame wall constructions. The calculated coefficients of transmission for various concrete constructions are tabulated in Table II together with the accepted coefficients for frame wall constructions.

TABLE II

Coefficients of Transmission, U, for Various Walls

Exterior Finish	Type of Sheathing	Interior Finish	U
Type I Construction (Fig. 6)			
a. Wood Siding	Gypsum (½")	Metal lath & plaster	0.33
b. Wood Siding	Wood (25/32") & building paper	Metal lath & plaster	0.26
c. Wood Siding	Wood (25/32") & building paper	Wood lath & plaster	0.25
Type II Construction (Fig. 6)			
a. Stucco	Gypsum (½")	Metal lath & plaster	0.43
b. Stucco	Wood (25/32") & building paper	Metal lath & plaster	0.32
c. Stucco	Wood (25/32") & building paper	Wood lath & plaster	0.30
Type III Construction (Fig. 6)			
a. Brick Veneer	Gypsum (½")	Metal lath & plaster	0.37
b. Brick Veneer	Wood (25/32") & building paper	Metal lath & plaster	0.28
c. Brick Veneer	Wood (25/32") & building paper	Wood lath & plaster	0.27

Concrete Construction (Results from this paper) Wall No.			Interior Finish	U
Concrete poured walls (7-7/8"), smooth surface.				
1	Sand & gravel	1:2.0:2.75		0.70
2	Limestone	1:4.75		0.66
3	Limerock	1:5		0.52
4	Limerock	1:7		0.49
5	Clinker concrete			0.28
Concrete block walls (7-7/8")				
6	Sand & gravel	1:2.0:2.75		0.58
7	Limerock	1:7		0.46
8	Sand & gravel	1:2.0:2.75	Metal lath & 3/4" plaster, furred	0.34
9	Limerock	1:7	Metal lath & 3/4" plaster, furred	0.30
10	Sand & gravel	1:2.0:2.75	Insulation board (½"), furred	0.24
11	Limerock	1:7	Insulation board (½"), furred	0.22

Thermal Expansion of Limerock Concrete

The rate of expansion of concrete with temperature is a property of scientific and technologic importance. It determines the spacing of expansion joints in structures and the type of reinforcing material usable in concrete. It may be expressed in several ways, of which the commonest is the mean coefficient of expansion, a. It is the increase of length $\Delta l = l_2 - l_1$, of the specimen, divided by the original length l_1, when heated over the temperature interval $\Delta T = T_2 - T_1$; that is, the change in length per unit of length per degree Fahrenheit rise in temperature.

$$a = \frac{1}{l_1} \frac{\Delta l}{\Delta T}$$

The method used for determining the coefficient of expansion of concrete was to measure directly, with an extensometer, the expansion in length which a beam undergoes when heated over a definite temperature interval. The extensometer was lagged with 1½" 85% magnesia insulation to eliminate temperature changes and was equipped with a dial guage which gave the expansion changes in 0.001". A stainless steel rod of known composition was used for checking the equipment and the method used in the laboratory. Since age and moisture content cause dimensional changes in concrete every effort was made to take each set of measurements at a constant moisture content and the same age.

The concrete specimens were made from 1:7 & 1:5 mixes by volume and were cast in the form of 3" x 3½" x 24" beams with stainless steel reference tips placed in the ends of each beam for accurate measurement of the length changes on heating. A thermocouple was cast in the center of each beam for use as a temperature measuring device. The center temperature was taken as the temperature of the whole beam.

When length measurements were made the reference point of one end of the concrete beam was placed on the base point of the extensometer and the top reference point of the beam was placed under the dial guage feeler. Since the tips of the reference points were rounded, the maximum dial guage reading was used each time. At the same time that length measurements were made, corresponding temperatures were measured for the concrete beam and extensometer beam so that accurate calculations could be made. Fig. 7 shows a concrete beam in the extensometer ready for a length measurement.

The stainless steel (18-8) rod used for checking the accuracy of the equipment and the method was ½" diameter and 24.7" long

Fig. 7—Concrete beam placed in the extensometer for making a length measurement

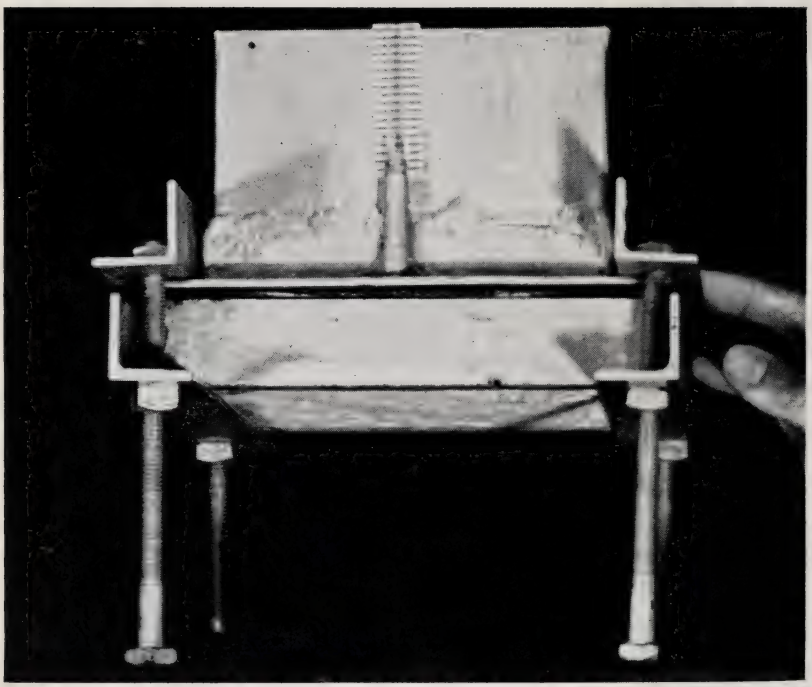

Fig. 8—Laboratory apparatus for measuring water transmission of concrete samples.

with the ends machined to have the same shape as the reference points set in the concrete. Two thermo-couples were soldered to the rod, one on the center and the other about 1″ from one end. Length measurements were made when both thermocouples indicated the same temperature. The completed rod was encased with 1½″ thickness of 85% magnesia insulation. Handbook data give the coefficient of expansion of stainless steel (18-8) as 9.8×10^{-6} foot per foot per degree Fahrenheit in the 70-212 F temperature range.

In the laboratory the average of 6 measurements on this rod gave 9.5×10^{-6}/F as the coefficient of expansion with a maximum deviation of any one measurement of $\pm 0.2 \times 10^{-6}$/F. Since the maximum deviation of any one measurement was rather small and the difference in values of the handbook data and these data could be explained on a basis of difference in heat treatment of the steel, it is believed that this method and equipment gives good results.

The data on concrete beams were taken in order to determine any effect moisture content would have on expansivity. From 28 observations made at different moisture contents on both 1:5 and 1:7 mixes it appears that any effect moisture content has upon expansivity must be negligible for no appreciable trend was found in a for moisture contents from dry to saturated. The following data on beam A2 (1:7 mix) is representative of the constancy of a with changes in moisture content:

Effect of Moisture on Expansivity

Moisture (% by weight)	a
12.0 (saturated)	3.3×10^{-6}
10.7	3.6
9.1	3.4
7.8	3.6
5.0	3.3
1.8	3.2
0.5	3.2
Average	3.4×10^{-6}/F

The results of 14 measurements on each pair of beams made from 1:5 and 1:7 mixes give expansivities as follows:

Effect of Composition on Expansivity

Mix	a	Max. Deviation
1:5 by volume	3.4×10^{-6}/F	±0.3
1:7 by volume	3.4×10^{-6}/F	±0.2

S. L. Meyers[7] gives the following values for expansivity of lime-

[7] S. L. Meyers, "Thermal Coefficient of Expansion of Portland Cement—Long Time Tests." *Indust. & Eng. Chem.*, 32: 1107-12, (1940).

stone concrete (1:3.1 mix) for different ages and storage conditions:

Effect of Age and Storage Conditions on Expansivity of Limestone Concrete

Hard Limestone Concrete

1:3.1 mix	0	½	1	2	4 yrs.
a. Dry Storage	5.0	7.9	5.3	3.9	3.4×10^{-6}/F
b. Enclosed air storage	2.9	3.2	3.3	3.4	3.0
c. Water storage	2.5	2.6	2.8	2.7	2.3

Thus our results are about the same magnitude as the values for hard limestone concrete under enclosed air storage conditions. Note the fact that water storage produces a material which is least affected by temperature expansions and that the expansivity does not change appreciably with age.

Meyers gives the expansivity of various concrete mixes as follows:

Effect of Richness of Mix and Different Aggregate on Thermal Coefficient of Expansion
(Data on 2 year-old samples)

Mix	$\alpha \times 10^{-6}$ per F
Neat normal cement	10.3
1 cement : 1 sand	7.5
1 cement : 3 sand	6.2
1 cement : 6 sand	5.6
Flint aggregate 1:4.7 mix	7.2
Sand aggregate 1:4.7 mix	4.8
Granite aggregate 1:4.7 mix	4.8

One point of universal agreement is that the coefficient of expansion increases with richness of mix as illustrated by the above data.

Engineers usually use an approximate coefficient of thermal expansion for ordinary concrete of 5.5×10^{-6} per F, and the expansivity of concrete reinforcing steel is generally taken as 6.0×10^{-6} per F. Then limerock concrete expands much less than ordinary concrete. As an example, the expansion of a 100 foot limerock concrete slab for an 80°F temperature rise amounts to only

$$3.4 \times 10^{-6} \times 100 \times 12 \times 80 = 0.33 \text{ inches.}$$

whereas, an ordinary concrete slab under similar conditions would expand much more,

$$5.5 \times 10^{-6} \times 100 \times 12 \times 80 = 0.53 \text{ inches.}$$

As a result expansion joints in limerock concrete need be smaller or less frequent than in ordinary concrete structures.

The effect of using reinforcing steel whose $\alpha = 6.0 \times 10^{-6}$ per F

with limerock concrete whose $a = 3.4 \times 10^{-6}$ per F is not known but the stainless steel reference points used in the test beams and whose $a = 9.8 \times 10^{-6}$ were still bonded tight after some of the beams have been heated and cooled over a 125 F temperature change as much as seven times.

WATER PROPERTIES OF LIMEROCK CONCRETE

Expansion of Limerock Concrete With Increase of Moisture.

Most materials change dimension with a gain or loss of water. Concretes are no exception—they increase in length on taking up water to the saturation point and decrease in length upon drying. Data in the literature on this phenomenum are very sparse; however, Miller and Snyder[8] found that the average expansion due to wetting clay tile (28-days in water) was 0.5×10^{-4} ft per ft of length, or 0.6″ per 1000′ tile and for dry tamped concrete tile the average expansion due to wetting was 4.6×10^{-4} ft per ft of length or 5.5″ per 1000 ft of concrete tile. Wendt and Woodworth[9] found that the expansion due to wetting a 1:3.45:2.3 (3.7 gal/sk mixing water) sand and gravel masonry unit was 3.7″ per 1000 ft.

This change of length with moisture content is probably of greater magnitude than is generally recognized by the construction men in the industry. Using Wendt and Woodworth's figure, a 16″ dry tamped concrete block if put up wet would contract 0.0059″ on drying out. This appears to be a negligible contraction, but it is probably enough to set up stresses in the block that would fracture occasional blocks in the wall.

The expansion of limerock concrete (plastic mix) due to wetting was measured by using the same technique and equipment described in the previous section. Two pairs of beams, 8 months of age, were used for measurement. The length of the bone-dry beams was measured and compared with the 28-day water soaked length of beam. The average expansion due to wetting was 3.3×10^{-4} ft per ft of length. There was no apparent difference in expansion between the 1:5 and the 1:7 mix by volume, although the 1:7 mix absorbs 13.0% moisture compared to 12.4% moisture absorbed by the 1:5 mix. This expansion of limerock concrete due to wetting is equivalent to the expansion resulting from a 95 deg F rise in temperature. Common practice is to design thermal expansion joints for an 80 deg F rise and neglect expansion due to wetting entirely.

[8]Miller, D. G. and Snyder, C. G. "Expansion of Clay and Concrete Drain Tile due to Increase of Temperature and Moisture Content." *Agri. Eng.*, 25: 179. (1944).

[9]Wendt, K. F. and Woodworth, P. M. "Tests on Concrete Masonry Units Using Tamping and Vibration Molding Methods." *Jour. Amer. Concrete Inst.*, 36: 27. (1939).

As a result of this experimental work, it appears that allowances should be made for expansion due to wetting in addition to the usual allowances for thermal expansion, especially if the structure is exposed to wetting and drying conditions.

Results of Water Transmission Measurements

Water leaks in concrete masonry walls occur from two sources, (a) porous areas and leaks in the units themselves, and (b) leaks in the mortar joints between the units. If the masonry units were completely sealed there would still be trouble with leaks through the mortar joints. The remedy for eliminating leaks from walls is to seal the outside surface of the finished wall. Sealing the units at the plant is only half the answer. Properly tooling the mortar joint will eliminate many leaks and put more emphasis on producing good, tight masonry units.

Test Work: The experimental work on this problem was conducted on slabs cut from commercial limerock masonry units. Commercial samples were used since they are analogous to an actual wall and will be more uniformly packed than a hand made product.

On testing 1¼"x7-3/4"x7-3/4" slabs cut from commercial masonry units it was found that of 21 samples tested only 4, or 19%, were "water tight"; that is, water did not leak through and drop from the underside of the block.

The test apparatus is shown in the accompanying photograph (Fig. 8). The test was designed to measure the rate of loss of water through the concrete slab when water is held on one surface of the concrete and free evaporation is allowed on the other surface. A calibrated container of distilled water was clamped onto the top side of the concrete slab and free air was allowed to circulate on the bottom side of the slab. The measurements were made on the basis of the amount of water passing through and evaporating from the underside of the slab per day. Two coats of aluminum pigment paint were used on the edges and face of each slab to limit the test area to 6"x6". All slabs were 1¼" in thickness. The absolute rate measurements are grams of water per day passing through a 36 sq. in. area of concrete 1¼" thick. Unless the slab was classed as leaky, a film of water never collected on the underside of the slab.

Various surface treatments have been applied to the leaky slabs in an effort to determine each treatment's effectiveness in sealing leaky concrete slabs and also in decreasing the water transmission rate of non-leaking concrete slabs. Each treatment was tested on two leaky concrete slabs to obtain an average result. Only 19% of the untreated slabs did not leak on test.

TABLE III

Summary of Treatment Processes with Test Results on Limerock Concrete Slabs

1 unit of water /(day) (36 sq in) = 0.28 lbs water /(day) (sq ft)

Material and Treatment	Water Transmission Rate units/(day) (36 sq in)	Remarks
Before treatment		
Red Clay Brick	1.5 to 2.0	
Untreated non-leaky Concrete Slabs	1.0 to 2.0	Only 19% did not leak
After treatment		
1. Asphalt Material		Very low rate after treatment. Emulsion penetrated pores very well. Poor color.
a. Emulsion applied in 2 coats with a stiff brush.	0.4	Three coats of asphalt did not seal leaks. Emulsion was more satisfactory to apply.
b. Cutback RCIS applied in 3 coats with stiff brush.	Leak	Poor color.
2. Na Silicate "o" Brand applied in 3 coats of dilute solution followed by an acid wash.	1.5	Two such treatments were required to seal leaks and then the water rate was not decreased. It produced a clean inert whitish surface.
3. Linseed Replacement Oil (Dutch Boy) applied by stiff brush in 4 coats.	0.5	Large number of coats required to seal leaks. Oil penetrated very well and was very effective in reducing water rate of concrete.
4. Zn Stearate applied in 10% kerosene solution by stiff brush in 2 coats.	2.4	One slab leaked after two coats. Surface was very water repellent.
5. Ethyl silicate. Three coats of a partially hydrolised solution were brushed on the surface.	2.3	This solution left the concrete surface in its natural color and some harder. Apparently it did not seal leaks very well for one slab leaked after 3 coats.
6. Vinyl copolymer paint applied by stiff brush in two coats.	0.2	Produced a lustrous film over the natural color concrete. Sealed leaks and had very low water transmission.
7. Synthetic resin paint Type B. Two coats were applied by stiff brush.	0.3	Gave very good results similar to Vinyl copolymer.
8. Ceramic seal coat cement. Two coats were brushed on with stiff brush and allowed to set.	1.5	Gave attractive finish and was good sealing material.
9. Limerock Cement Paint. Two coats of a 1:2 weight cement: limerock (-100 mesh) mix were brushed on with stiff brush.	0.9	Sealed leaks very well and had fairly low water transmission.
10. Limerock Cement water Repellent Paint. Same as No. 9 except 1% Al stearate based on cement and limerock was added.	1.0	Sealed blocks effectively and gave water repellency to surface. This would probably be a great advantage on vertical walls.

The emulsified asphalt was very effective in sealing the leaks and pores in the concrete. When the emulsion is put on with a stiff brush it appears to penetrate the pores and holes in the surface very well. The black color is objectionable.

The vinyl copolymer and synthetic resin base paints gave good results on sealing the leaks in the slabs and both had very low water transmission rates. They are probably too expensive ($5-$6 per gallon) to be considered for general use.

The ceramic seal coat cement gave good results as a sealing compound but the water transmission rate is higher than that of cement-water paints.

At present the most satisfactory solution to the waterproofing problem from both cost and performance viewpoints, is the use of portland cement-water paints. Tests show that the cement-water paints were very effective in sealing the leaks in the surface and they also lower the water transmission. They are the cheapest and most durable treatment tested. Adding 1% of aluminum stearate to the cement paint before mixing gives water repellent properties to the paint film. By actual tests made on an ordinary cement paint film and a water repellent cement paint film (1% aluminum stearate) it was found that water dropped on the ordinary cement paint penetrates into the film in 10 to 15 seconds as compared to no penetration of the water drops into the repellent film on standing 3 to 4 hours. In fact, the water drops on the repellent surface evaporate before they penetrate the film. The repellent films have the same water transmission as ordinary cement paint films.

The National Bureau of Standards in "Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls"[10] found that cement-water paints were more effective as waterproofings than oil-base and emulsified resin paints. They also found that bituminous coatings applied to the inside faces of brick walls were ineffective as water-proofings and that brush coatings of portland cement and sand were more effective.

The American Concrete Institute Committee 616 report on "The Nature of Portland Cement Paints and Proposed Recommended Practice for Their Application to Concrete Surfaces"[11] covers the composition, mixing, and application of cement-water paints to concrete surfaces.

It appears that there is no reason for a leaky concrete wall to exist when cement-water paints are available.

[10]Obtainable from Superintendent of Documents, Washington, D. C. as Building Materials & Structures Report BMS 95, Price 15c.

[11]*Jour. Amer. Concrete Inst.*, 13: 485-501. (1942).

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